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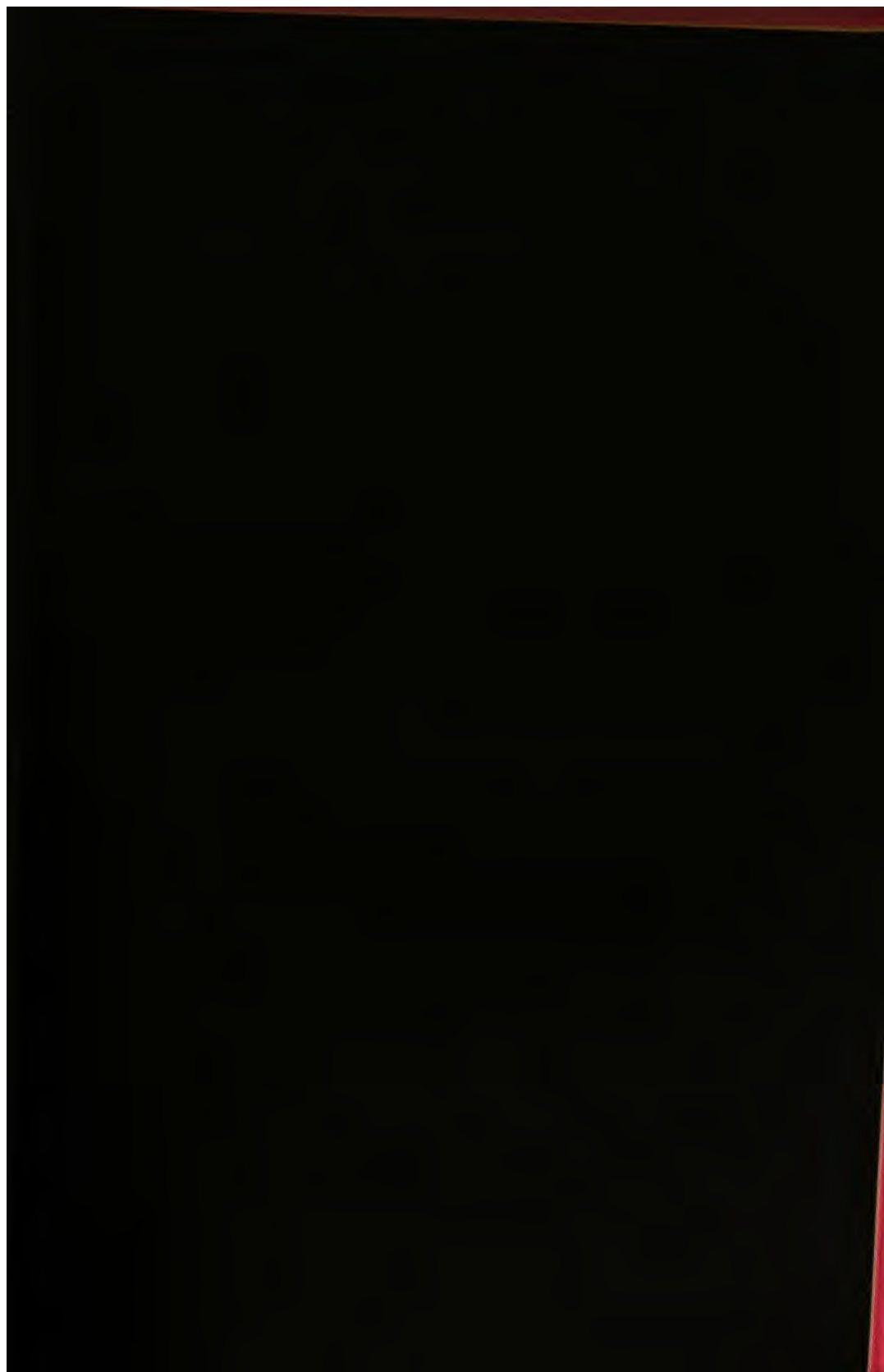
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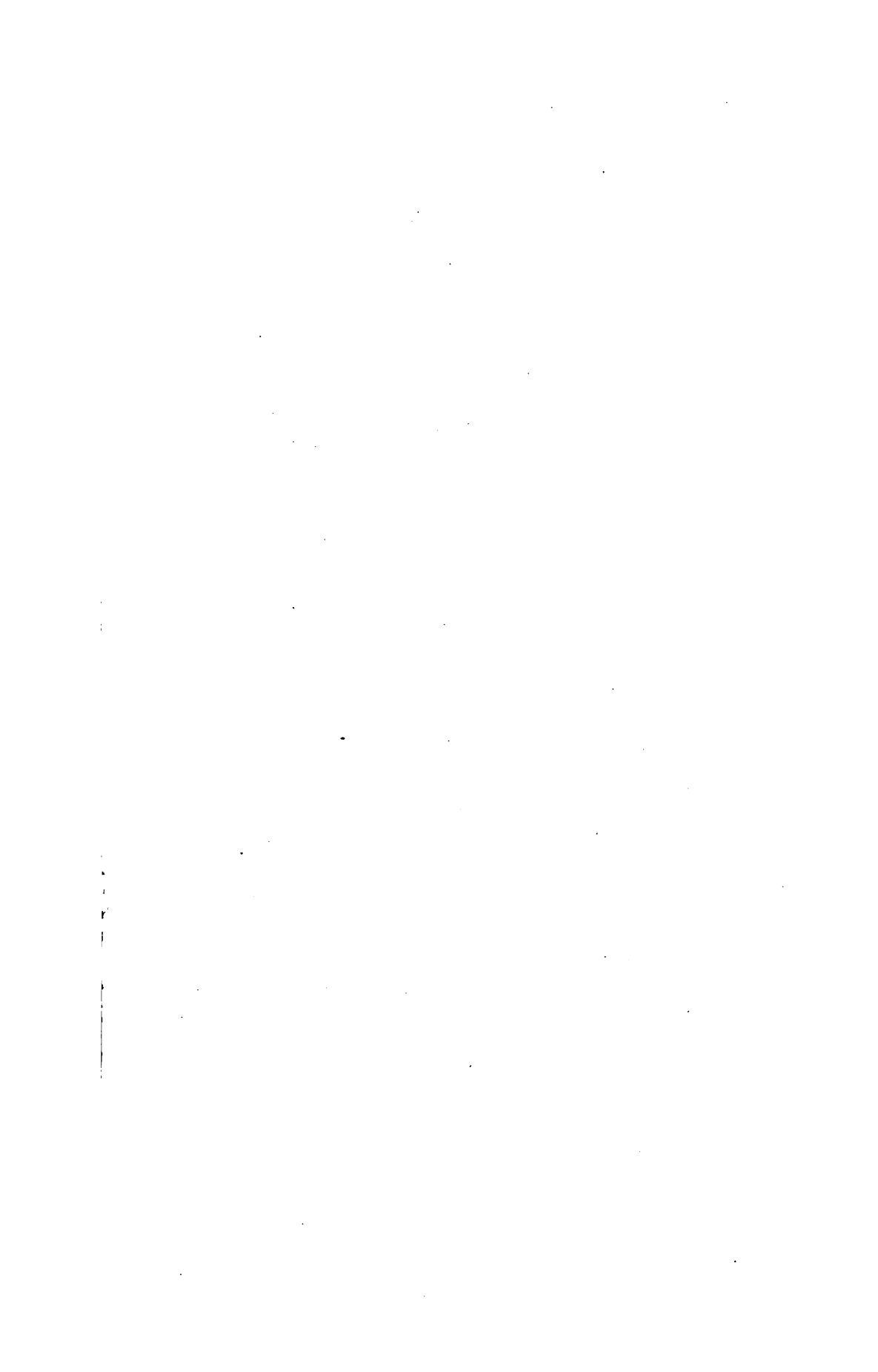
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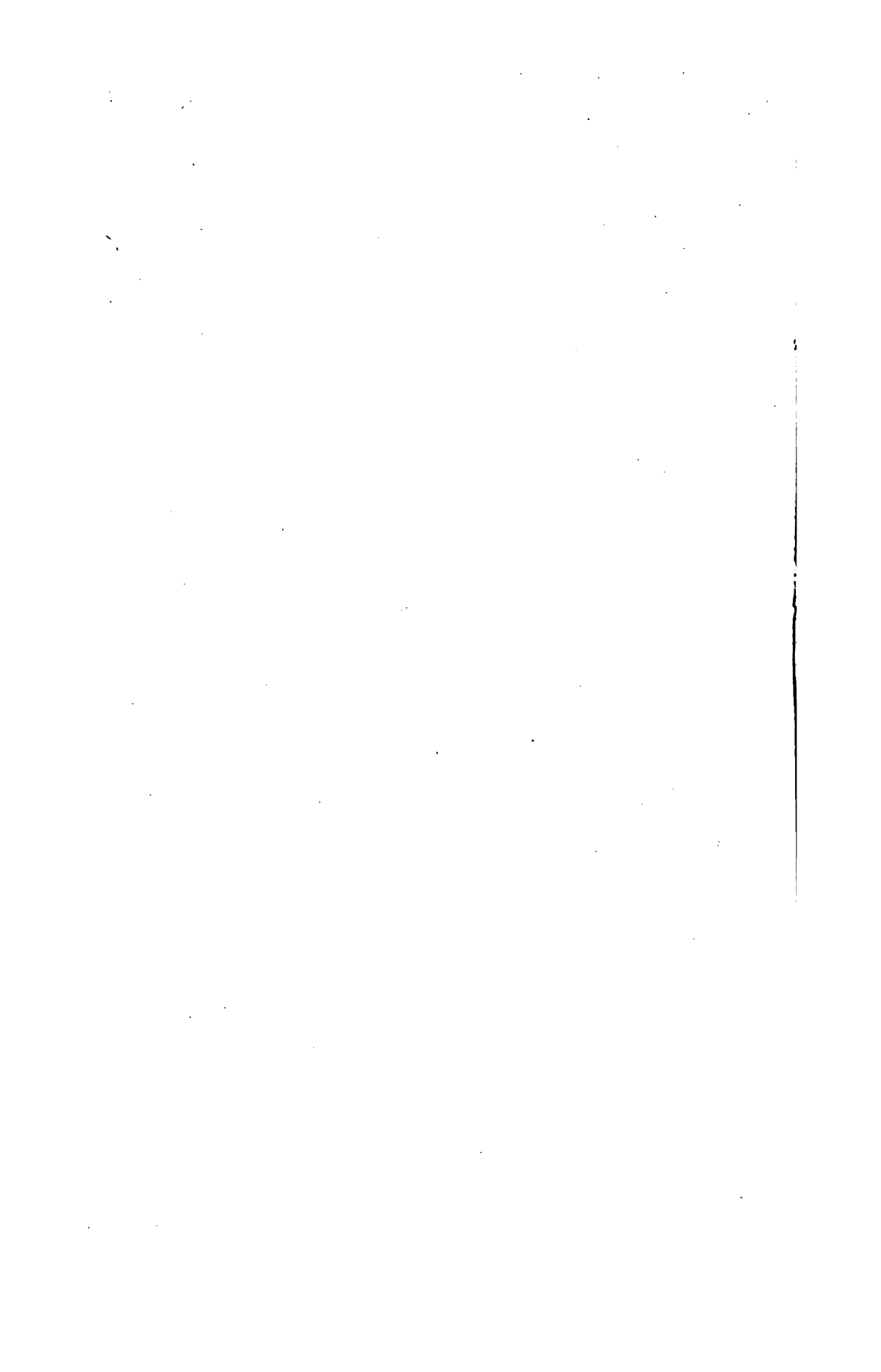
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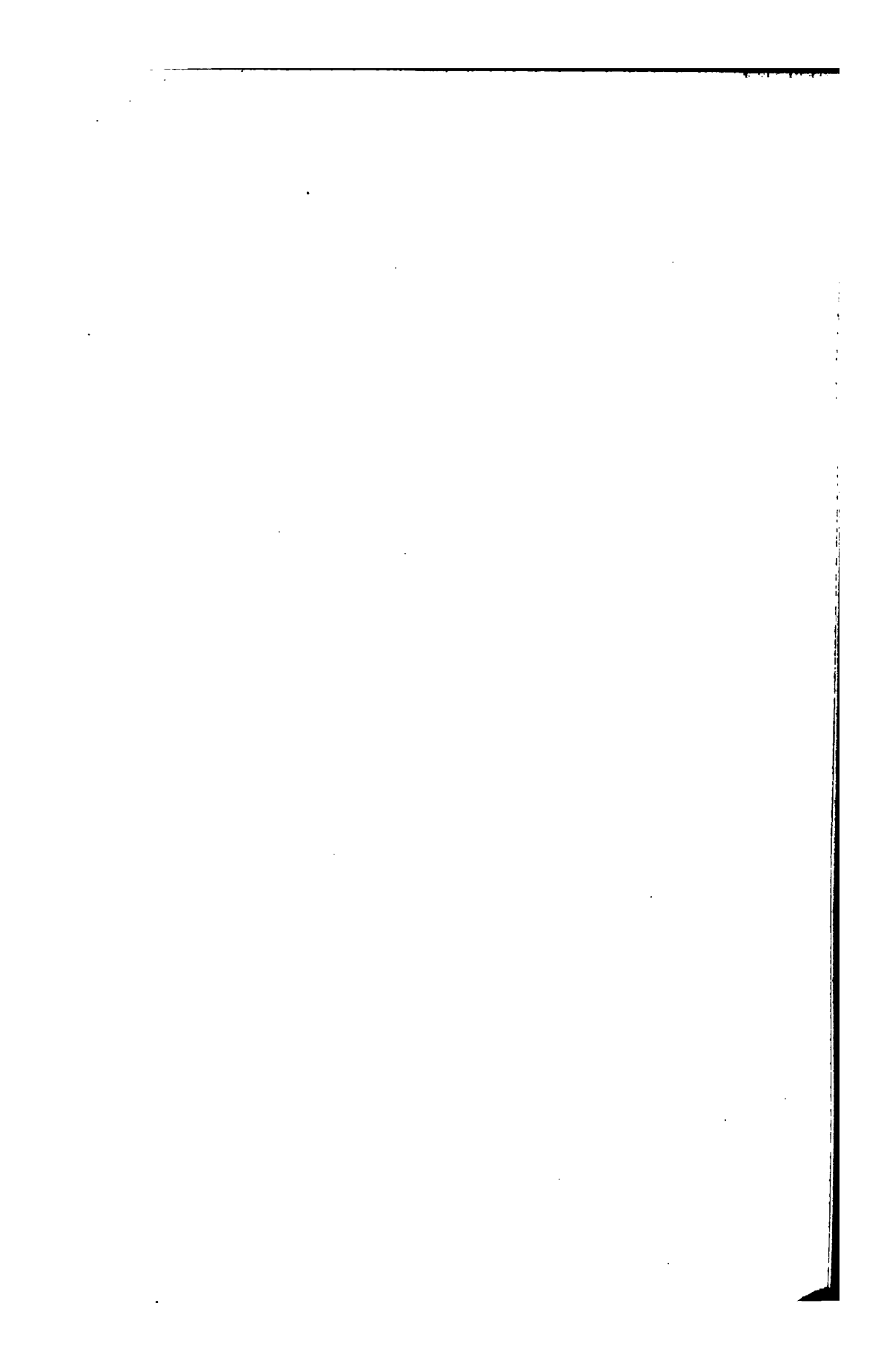
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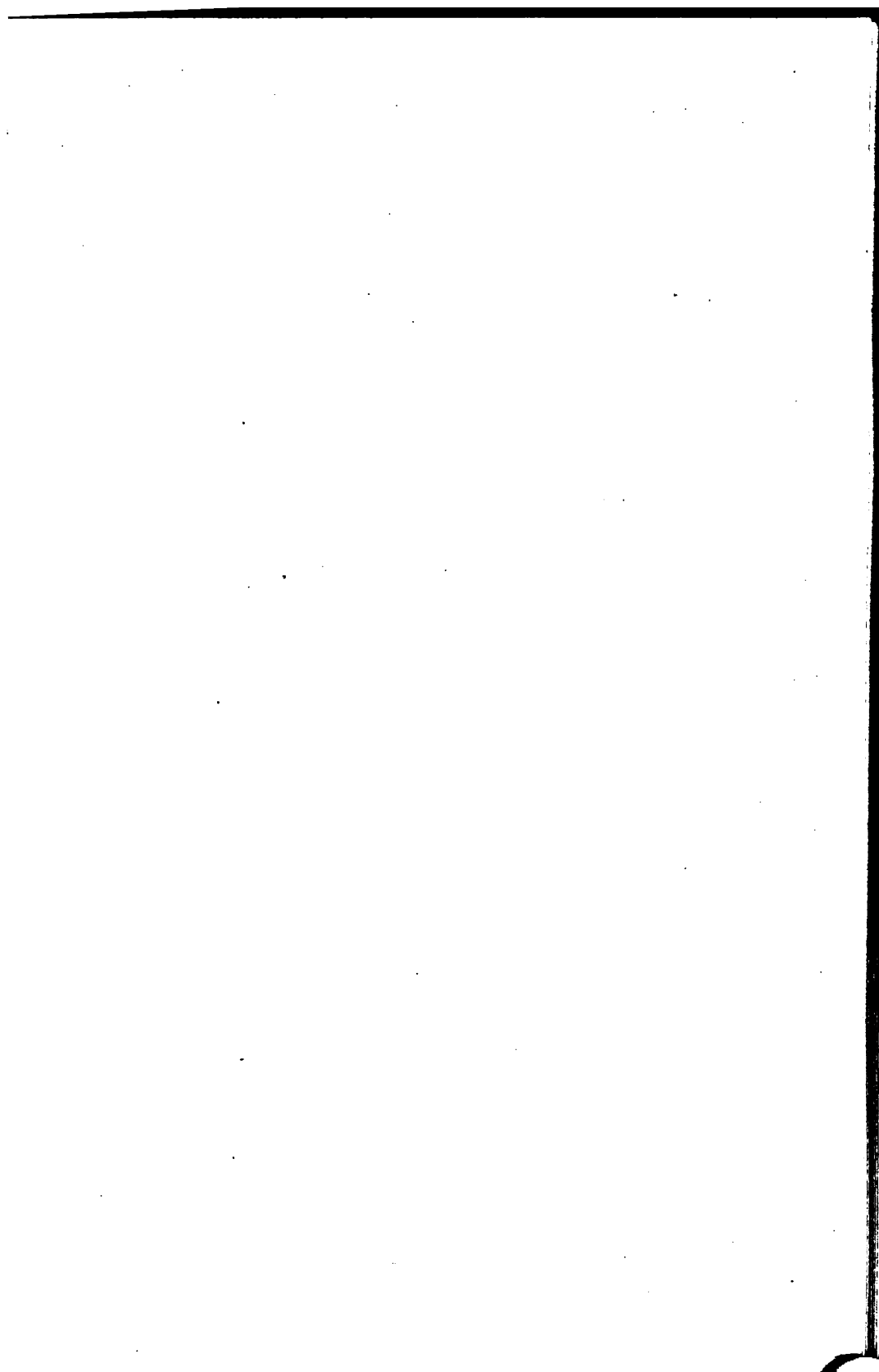












APPLEBY'S ILLUSTRATED HANDBOOK OF MACHINERY.

SECTION III.—PUMPING MACHINERY.

PUMPING PLANT, WORKED BY STEAM, ELECTRIC,
ANIMAL AND MANUAL POWER,
FOR
TOWN SUPPLY, IRRIGATION, MINE AND SURFACE DRAINAGE,
MANUFACTURING, AND DOMESTIC SERVICE,
WITH
*PRICES, WEIGHTS, MEASUREMENTS, AND SOME NOTES ON
INSTALLATIONS,
POWER REQUIRED AND RESULTS OBTAINED.*

BY

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22, WALBROOK, LONDON, E.C.

Telegraphic Address—"MILLWRIGHT, LONDON."

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APPLEBY'S HANDBOOK OF MACHINERY.

THE Edition published in 1869, and several reprints of it, having been exhausted, a NEW EDITION (of which this section forms a portion) is now being completed ; and for the convenience of those who desire information on specific subjects, but not on all those treated, the book is divided into seven sections, each of which may be obtained separately as follows :—

SECTION 1.—PRIME MOVERS.

STEAM, GAS AND AIR ENGINES, BOILERS, DYNAMOS, MOTORS, TURBINES, ETC.

SECTION 2.—HOISTING MACHINERY.

WINDING ENGINES, HYDRAULIC, STEAM, ELECTRICAL AND HAND CRANES.
WINCHES, JACKS AND OTHER LIFTING APPLIANCES.

SECTION 3.—PUMPING MACHINERY.

PUMPING ENGINES, CENTRIFUGAL, STEAM, ELECTRICAL AND HAND PUMPS.

SECTION 4.—MACHINE TOOLS AND ACCESSORIES.

FOR WORKING METALS, WOOD, ETC.

SECTION 5.—CONTRACTORS' PLANT AND RAILWAY MATERIALS.

INCLUDING MACHINERY AND MATERIALS FOR THE CONSTRUCTION AND
EQUIPMENT OF RAILWAYS AND OTHER PUBLIC WORKS.

SECTION 6.—MINING, COLONIAL AND MANUFACTURING MACHINERY.

FOR TREATING ORES, CORN, COFFEE, RICE, SUGAR, COTTON, AND OTHER
PRODUCTS, OIL MILLS, ICE MAKING, DISTILLING, ETC.

SECTION 7.—USEFUL TABLES AND MEMORANDA.

FOR ENGINEERS, MERCHANTS, AND MANUFACTURERS.

Each Section, bound in cloth, is sold separately, price 3/6 each.

The subject matter has been entirely re-written, and is illustrated by a large number of Engravings which (for the most part) represent work carried out by the Author's Firm.

The arrangement is intended to be in a handy form for reference, useful alike to engineers, users, and to purchasers of machinery and of materials connected therewith.

The prices are based on the present cost of materials and of labour, and these—as well as details of design and proportions—are necessarily subject to modification without notice.

Some data is given with reference to the cost of working, motive power required and work performed ; also approximate weights and measurements, so that the results obtainable and the total cost including freight, import duties, etc. may be roughly estimated. The cost of packing for shipment and delivery to docks varies with the nature of the packing required and the destination, the rates given being the average as nearly as they can be determined.

Code Words for each kind of machine will be found in the index, and these, in conjunction with the sentence words in Appleby's Copyright Telegraph Code which precedes the Index, will usually suffice for correspondence by cable ; by specifying the price, Fig. No., or page in figures, the leading dimensions of the tool required can be indicated. An example of the mode of using this and other codes will be found at page IV.

PREFACE.

Much information relating to the matters referred to in the following pages will be found in text books, treatises, and trade catalogues, but it is treated, for the most part, in a manner too technical to be of real service to many who—although buyers and users of machinery—may not possess intimate knowledge of details of construction, the cost of machines, their productive capacity, &c.

Conscious, as the Writer is, that the efforts of no single individual will suffice to cover the ground thus left vacant, he has endeavoured to present information with regard to the construction, the approximate prices of the machines described, the probable output, and other data which will serve as a basis for estimating the cost of most types of the machinery in general use to which reference is made and, approximately, the cost of working it.

The arrangement adopted in the first edition of APPLEBY'S HANDBOOK OF MACHINERY, which was published in 1869, has been to a large extent adhered to in this edition, but since that time, the advances made in all branches of mechanical construction have been so incredibly great and varied, that nothing which appeared in the above-named edition, or the numerous reprints of it, has been found suitable for reproduction, so that the descriptive matter has been entirely re-written and—as far as practicable—corrected up to this date.

Sections 1, 2, 3, 4 and 6 may now be obtained through any Bookseller; the two remaining volumes (5 and 7) will be completed as early as possible.

London,
October, 1901.

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APPLEBY'S COPYRIGHT CODE

FOR CORRESPONDENCE BY TELEGRAM.

TELEGRAPHIC ADDRESSES { "JESSOP, LEICESTER."
RESPECTIVELY : "MILLWRIGHT, LONDON."

The code numbers are for use in case a repetition of the telegram may be necessary.

ENQUIRIES AND QUESTIONS.

191290	Taaier	...Telegraph how soon you could ship the following, viz.....
191291	Taaiheid	...Reply, by letter, how soon you could ship the following, viz.....
191292	Taainagel	{ Telegraph at what price, packed and delivered f.o.b. English port, you could supply and ship the following, viz.....
191293	Taalboek	{ Reply, by letter, at what price, packed and delivered f.o.b. English port, you could supply and ship the following, viz.....
191294	Taaldeel	{ Telegraph how soon and at what price, packed and delivered f.o.b. you could supply and ship the following, viz.....
191295	Taaleigen	{ Reply, by letter, how soon and at what price, packed and delivered f.o.b. English port. you could supply and ship the following, viz.....
191296	Taalfout	...Telegraph name of vessel by which you have shipped.
191297	Taalgebrek	{ We learn that the.....with your goods on board has been lost. Shall we replace ?
191298	Taalgids	...Telegraph, at my expense, how soon my order will be despatched ?
191299	Taalgrond	...Reply, by letter, how soon my order will be despatched.
191300	Taalkundig	...Do you wish us to proceed with order ?
191301	Taalman	...Will you leave matter to our discretion ?
191302	Taalregel	...When will remittance be sent for £.....
191303	Taalschat	...Send us a complete tracing of.....
191304	Taalteeken	...Send us a photograph of.....
191305	Taalvitter	...Send us a complete estimate for the following
191306	Taalvriend	{ Prepare design and send tracing and estimate including delivery f.o.b. for.....
191307	Taalwet	...Can you alter the goods to our order as follows.....
191308	Taalzifter	...How soon can you deliver ?
191309	Taanbloem	...Have you in stock ?
191310	Taartblik	...A reply by wire is requested.
191311	Taarten	...A reply by first mail is requested.

ORDERS AND INSTRUCTIONS.

By Sailing Vessel.	Steamer.	Mail Boat.	
191312 Taartepan	191313 Taartjes	191314 Taartkoek	{ Please supply and ship as soon as possible the following goods, engaging freight and insurance, free of particular average. Please supply and ship as soon as possible the following goods, engaging freight and insurance, free of all risks, if latter is possible.
191315 Tababocca	191316 Tabacalero	191317 Tabacales	
191318	Tabaccasse	...No part of the machine must weigh more than.....cwts.	
191319	Tabacchi	...We leave matter to your discretion.	
191320	Tabacomane	...Preferring them in the order named.	
191321	Tabacosas	...Payments may be made by.....	
191322	Tabacoso	...Payments will be made by	Arrange terms with that firm.
191323	Tabagie	...Terms will be as before.	
191324	Tabagique	...Remittance is delayed until.....	
191325	Tabahia	...Draw on us at sight for £.....	
191326	Tabakasche	...Draw on us at.....	
191327	Tabakbau	...Await instructions for shipment.	
191328	Tabakbeize	...Replace with all possible despatch.	
191329	Tabakdampf	...Duplicate our order of.....	
191330	Tabakkorb	...Repeat our order for.....	
191331	Tabakladen	...Repeat our last order.	
191332	Tabakqualm	...Await our letters before proceeding.	

Orders and Instructions—Continued.

191333	Tabakrauch	... Same pattern or quality as before.
191334	Tabakreibe	... The same as you last supplied.
191335	Tabakrolle	... Same as supplied by you in.....
191336	Tabaksblad	... Same as supplied by..... in.....
191337	Tabaksbouw	... Same as supplied to..... in.....
191338	Tabaksland	... Draw on us for £..... at the following number of days from sight.
191339	Tabakspijp	... Please deliver at once.
191340	Tabaksrook	... Please deliver next week.
191341	Tabakstube	... Must be inspected by.....
191342	Tabaksvat	... Ship at once.
191343	Tabaksveld	..... has been irreparably damaged send another.
191344	Tabakszak	..... has been lost replace it immediately.
191345	Tabaleabau	... Please send by next mail certificate for.....
191346	Tabaleara	... Prepare for delivery at once.
191347	Tabaleos	... Wanted for immediate delivery.
191348	Tabalhiom	... The makers were (are).....
191349	Tabaliado	... As described in Appleby's Handbook of Machinery, price £.....
191350	Tabanidae	... As illustrated in " " " Fig.....
19134A	Tabanus	... As described in " " " page.....

ANSWERS, &c.

19134B	Tabanca	... Freight will add about..... per cent. to the f.o.b. cost.
191351	Tabanquet	... The machine will weigh about..... cwt.s.
191352	Tabaquear	... The total weight will be about..... tons.
191353	Tabaqueiro	... The total measurement will be about..... cubic feet.
191354	Tabaqueras	... No part of the machine will weigh more than..... cwt.s.
191355	Tabaqueurs	... The machine is finished.
191356	Tabaquista	{ We can supply you with goods, as per your enquiry, at the following net price.
191357	Tabardelha	{ Please telegraph credit with some English Bank for order just received.
191358	Tabarder	{ The credit opened with the Bank is too small; please to telegraph further credit for £.....
191359	Tabardilho	... We cannot execute order on other terms.
191360	Tabarzet	... We have remitted you by letter £.....
191361	Tabatiere	... Cash will be paid against Bill of Lading by.....
191362	Tabaxir	... Machinery is shipped by steamer.
191363	Tabbard	... Machinery will be shipped by steamer.
191364	Tabbaoth	... Machinery is shipped by sailing vessel.
191365	Tabbinet	... Machinery will be shipped by sailing vessel.
191366	Tabbying	... Your order received and has our best attention.
191367	Tabebuia	... Remittance follows by mail.
191368	Tabefatto	... Remittance will be sent immediately for £.....
191369	Tabefied	... Waiting for remittance.
191370	Tabellaria	... Credit arranged through.
191371	Tabellaron	... Credit arranged by telegraph.
191372	Tabelle	... £10 additional needed to cover cost.
191373	Tabelliar	... £20 " " "
191374	Tabellioa	... £30 " " "
191375	Tabellions	... £40 " " "
191376	Tabellone	... £50 " " "
191377	Taberd	... £60 " " "
191378	Tabergite	... £80 " " "
191379	Tabernacle	... £100 " " "
191380	Tabernero	... £ " " "
191381	Tabescence	... We can deliver from stock.
191382	Tabescent	... " " " in one week.
191383	Tabetique	... " " " in two weeks.
191384	Tabicadas	... " " " in three weeks.
191385	Tabicamos	... " " " in four weeks.
191386	Tabicar	... " " " in six weeks.
191387	Tabicaron	... The time for delivery should be..... weeks.
191388	Tabicones	... The time of delivery is of great importance.
191389	Tabido	... All charges will be accounted for.....
191390	Tabificas	... All charges will be paid by.....
191391	Tabiflui	... I (we) cannot promise delivery until.....
191392	Tabifluos	... I (we) cannot promise delivery in the time stated, letter follows.

Answers, &c.—Continued.

191393	Tabiosis	...	{ I (we) cannot promise delivery in time stipulated, please telegraph instructions.
191394	Tabique	...	...We have not received yours of the.....
191395	Tabiqueis	...	...Replying to your telegram, (enquiry) our price is £.....
191396	Tabiquemos	...	{ Replying to your telegram, our price, subject to prompt confirmation of order, will be £.....
191397	Tabiser	...	...Full information follows by mail.
191398	Tablacho	...	...Tracing and estimate will be sent.
191399	Tablabo	...	...Tracing and estimate were sent.
191400	Tablajero	...	...We have received your order for.....

GENERAL MESSAGES.

191401	Tablares	.....	steamer is delayed by having to put in at.....
191402	Tablazones	.....	...is erected and works satisfactorily.
191403	Tablazos	.....	...is erected but does not work satisfactorily.
191404	Tableabais	...	{ is erected but does not yet work satisfactorily, send immediately by quickest route.. ..
191405	Tableadas	.....	...will leave on or about the.....
191406	Tablearia	.....	...cannot leave before the.....
191407	Tablearon	.....	...is completed.
191408	Tableaux	.....	...I (we) will see you on or about
191409	Tableros	.....	...We must have dimensions, sketches, or drawings.
191410	Tabliers	.....	...We require more detailed information with reference to
191411	Tabliha	.....	...We are sending you additional information with reference to
191412	Tablon	.....	...We last heard from you on the.....
191413	Tabloza	.....	...Refer to our letter dated.....
191414	Taboas	.....	...Refer to our telegram dated.....
191415	Taboinha	.....	...We refer to your letter dated.....
191416	Tabolagem	.....	...We refer to your telegram dated.....
191417	Taboleiro	.....	...Have you received our order for.....
191418	Taboleta	.....	...We have not received your order for.....
191419	Tabooed	.....	...Please send necessary instructions.
191420	Taboriten	.....	...Please send confirmation by letter.
191421	Tabouer	.....	...We forward by steamer advertised to close on the.....
191422	Tabouret	.....	...Can you forward by the.....
191423	Tabourine	.....	...The Bill of Lading must be to the order of
191424	Tabraca	.....	...The Bill of Lading must be sent to....
191425	Tabrimon	.....	...The Bill of Lading has already been sent to.....
191426	Tabual	.....	...The Bill of Lading has not been received.
191427	Tabuda	.....	...Delivery cannot be made until we have the Bill of Lading.
191428	Tabularize	.....	...Have you received the Bill of Lading.
191429	Tabulating	.....	...Insure to cover cost, freight and insurance.
191430	Tabulista	.....	...Insure to cover all charges and risks if latter is possible.
191431	Taburno	.....	...We accept your order for.....
191432	Tacahout	.....	...We accept your order dated
191433	Tacamaca	...	{ We cannot accept your order on terms proposed, please refer to our offer.
191434	Tacca	.....	...Forward as early as possible.
191435	Tachylite	.....	...We accept your offer dated.....
191436	Tachypetes	.....	...We can carry out your proposals at extra cost of £.....
191437	Tacitly	.....	... " " " " without extra cost.
191438	Taciturn	.....	...Details of conditions are sent by mail.

DIMENSIONS, &c.

191611	Taffetas	.....	...The diameter of steam cylinder to be.....inches.
191612	Taffetband	.....	...The diameter of pump barrel to be.....inches.
191613	Taffety	.....	...The length of stroke is.....inches.
191614	Taffeur	.....	...The maximum quantity delivered per minute is.....gallons
191615	Taffrails	.....	...The maximum height of lift is .....feet.
191616	Tafilet	.....	...The steam pressure available at pumps is lbs.....
191617	Tafiletero	.....	...All suction and delivery pipes will be provided.
191618	Tafnacht	.....	...The diameter of water pipes is..... inches.
191619	Tafografia	.....	...The length of water pipes will be.....feet.

NOTE.—These figures may be given in metrical measures, if so stated.

EXAMPLES OF TELEGRAMS IN APPLEBY'S CODE

The following exchange of Telegrams shows the mode in which this Code may be used. A correspondent telegraphs, "**Taaldeel Cabellera Tabanidæ 2512 tabaksrolle 1885,**" which on reference to the Code will be found to read as follows :

"Telegraph how soon and at what price, packed and delivered f.o.b. you could supply and ship the following, viz. : Compound Condensing Horizontal Pumping Engines, as illustrated in Appleby's Handbook of Machinery, Fig. 2512 ; same as supplied by you in 1885."

THE REPLY to this was "**Tabiquies 2650 Tabicarón 21.**" which reads : "Replying to your Telgram (inquiry) our price is £2650 ; the time for delivery should be 21 weeks."

THE ACCEPTANCE of this offer reads :—"Taartjees Cabellera Tabagie : " or "Please supply and ship by steamer as soon as possible the following goods, engaging freight and insurance free of particular average, Horizontal Compound Surface Condensing Pumping Plant, terms will be as before."

EXAMPLES OF TELEGRAMS IN THE A1 TELEGRAPHIC CODE.

The Code words at page i. to xi. conflict, to some extent, with those in the widely used A1 Code, but no confusion can arise if the latter is used *exclusively*, the subjoined (or other agreed) words being employed to clearly identify the Section of the Handbook referred to, thus :—

APPLEBY'S HANDBOOK OF MACHINERY, SECTION I.	...	...	Admugitum
"	"	II.	Adnatobat
"	"	III.	Adociria
"	"	IV.	Adoliridas
"	"	V.	Adumbrato
"	"	VI., PART A.	Adonteremo
"	"	VI., PART B.	Adopertus
"	"	VII.	Adoptames

followed by the Code words at page 1180 (1888 edition) which—in the sequence in which they are used—indicate respectively (1) the page referred to and (2) the number of line from top of printed matter on that page. Code words for dimensions, weight, etc., will be found at pages 1032 to 1052.

Example.—A correspondent who requires Centrifugal Pumping Machinery with Compound Engine and Boiler to raise 2500 gallons per minute (150,000 gallons per hour), to a height of 27 feet as illustrated and described in this volume, cables : "**Feribile Enrhumér Truchuela Exhalais Trasoneria Trasgueado Adociria.**"

On reference to the A1 Code the message will be found to read as follows : "Forward immediately by steamer Centrifugal Pump, Compound Engine and Foiler Combined, 150,000 gallons per hour against 27 feet head, page 70, line 2 ; of Appleby's Handbook of Machinery, Section III."

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COPYRIGHT TELEGRAPHIC CODE.

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SECTION III.

PUMPING MACHINERY.

PUMPING MACHINERY.

History affords ample evidence of the early period at which mechanical appliances for raising water were employed, and examples of some of them have been transmitted to us in the "Shodouf" and the "Sakieh," which are still commonly used in Egypt and (with modifications) in Eastern countries, just as they were long prior to the Christian era.

The vast strides made since the period above referred to unquestionably owe their existence to the invention of the steam engine, and volumes would be required to represent the more important types of pumping machinery which have been devised during even the last thirty years, so that the illustrations and descriptions now given must be limited to typical pumping plant of modern design, leaving other arrangements to be dealt with when the working conditions have been ascertained.

Water supply by gravitation is (naturally) the most economical, but the quality and quantity of water required for a town supply can rarely be obtained at an elevation sufficient to deliver the water to the user through the mains and service pipes.

In the absence of such a supply, attention is directed to arrangements similar to those indicated in Figs. 2510 and 2511, whereby the volume of surplus water is utilized for generating power to drive the pumps for the city supply.

Pumping plant.—Most types of machinery for raising water are represented in the following pages from the modern direct-acting triple-expansion engine to the common hand pumps, and the conditions to be fulfilled having been determined, it will probably not be difficult to select the appliances which will fulfil them.

Pipes and connections.—The pipes should be of ample diameter, in proportion with their length, to minimise the loss in friction, and for the same reason sharp bends or inequalities should—as far as possible—be avoided. If inequalities in levels are unavoidable, a valve or cock will be required at the highest point to allow imprisoned air to escape.

Friction in pipes increases directly in the ratio of length and, approximately, as the square of the velocity of the flow.

Suction pipes.—It is well known—but by no means always remembered—that the so-called "Suction" is due merely to the pressure of the atmosphere which, at sea level, is 14·7 lbs. per square inch, or equivalent to a column about 30 feet high, so that the foot of the suction pipe must always be immersed, and (allowing for possible leakages) must in no case be more than 27 feet from lowest water level for large pumps and less than that for small pumps, the height being reduced in proportion, with increase in temperature of the water beyond about 55°. When boiling point (212°) is reached the water must flow freely into the pump with a head of not less than 2 or 3 feet.

If the suction pipe cannot be carried vertically from the pump to the water, it should rise gradually and be provided with a foot valve. A strainer is obviously desirable, unless the water is exceptionally free from floating matter.

Where a "Sumph" cannot be provided, of sufficient depth to allow stones, sand and debris to settle below the intake to the pumps, it should be protected by a box which will maintain a fairly undisturbed surface around the suction pipe. For large pumps an arrangement similar to that indicated in Fig. 1626 (Section 1) may be adopted with advantage.

Joints of pipes and connections.—These should be carefully made to guard against leakage of air and water. Much loss of time and labour may be avoided if pipes are thoroughly tested when laid, and before they are covered.

Air vessels and stand pipes are necessary adjuncts for equalising the flow of water. The stand pipe which is open to the atmosphere at the top, effectually limits the pressure in the rising main to that due to the height of the stand pipe.

Velocity of water in pipes.—This question is largely affected by the conditions fulfilled by the pump. From 2 to 4 feet per second is a convenient velocity for comparatively small pumps which are in constant use, whilst for a centrifugal pump (especially if worked intermittently and discharging at or near the pump) a velocity of 10 to 12 feet per second, although not economical, is not at all exceptional.

Coating pipes with the well-known "Dr. Angus Smith's" Composition, protects them from corrosion and greatly retards the accumulation of deposit. Pipes for water highly charged with some acids require different treatment, the nature of which can only be determined after analysis of the water.

Valves and pumps.—If the pumps are required to raise sewage or water charged with glutinous or insoluble matter, chemicals, etc. the conditions should be clearly described to enable the necessary provisions to be made.

Reciprocating pumping engines.—Triple expansion and high speed pumping engines are now largely employed, but the well-known Cornish pumping engine for draining mines, and the beam engine for town supply, still hold a high position on account of their undoubted durability and economy. The recorded duty of some of these engines is 90 to 100 millions of foot pounds for each bushel (about 100 lbs.) of coal consumed, and many which have worked continuously for more than half-a-century are still doing excellent service. Similar results are, however, now obtained by the use of high pressure steam in conjunction with direct acting engines of the marine type and treble or quadruple expansion.

Rotating and direct acting engines can usually be installed at short notice and the total cost of machinery, foundations, buildings, etc., is so much less than that of pumping plant, of equal capacity, of the older and more durable types, that both convenience and economy in first cost may be in favour of the modern engines referred to in the following pages.

Centrifugal pumps (although less economical in consumption of fuel than reciprocating pumps) are unequalled for moving large quantities of water through the low lifts usually requisite for **drainage and irrigation**, the service of **floating and graving docks, wreck raising and dredging**, circulating water for **surface condensers** and innumerable other purposes.

The nearer the pump is to the water, the greater will be the useful effect; circumstances may render a long suction desirable, but it ought not to exceed about 25 feet in vertical heights for any size, and for pumps with pipes of 5 inches diameter, or less, the height above lowest water level should be limited to 15 to 20 feet.

The three modes of driving in general use are illustrated in Figs 2565 to 2572, and the only remark to be made on this branch of the subject is, that driving by belt, or by an engine or electric motor on the end of the pump shaft is usually preferable to driving by gear, although, under some circumstances this is almost a necessity.

Duty of centrifugal pumps.—The following table, based on an ascertained efficiency of 70 per cent., gives the horse power required for each foot of lift, and applies to pumps driven by belt or other efficient means and working at the speed necessary to deliver the water at a velocity of 5 to 6 feet per second.

If the velocity of delivery is increased, the same pump lifts more water, but with a greater proportionate expenditure of power.

Diam. of pipes inches	3	4	5	6	7	8	10	12	14	15
Gallons per minute	90	160	280	400	550	750	1200	1770	2300	2700
H.P. per foot lifted	.0389	.0692	.1212	.1732	.2381	.3246	.5195	.7792	.9956	1.169

Electric pumps.—The absence of noise, vibration and heat, and the facility with which power is transmitted, almost regardless of distance or direction, are features which will inevitably lead to an extended use of electricity as a motive power for driving pumps. The speed of the motor renders it peculiarly applicable to centrifugal and other pumps requiring a high and quickly developed speed.

Pumps worked by hydraulic pressure consist, essentially, of two hydraulic cylinders which are supplied with water at the pressure required to impart motion to a pair of single acting plunger pumps and deliver a given volume of water at the height desired. This system of pumping is illustrated in Fig. 2507, and is less generally known than one so simple and efficient deserves to be.

Pulsometers.—Water lifters of this type are useful and even almost indispensable under some conditions, but they do not compare favourably, in fuel economy, with most of the pumps above referred to.

Boiler feed pumps, injectors and ejectors are referred to in section 1 in connection with Steam Boilers and Condensers, and (for convenience in reference) are included in this volume.

The direct acting pumps which take steam, practically, throughout the stroke, as is pointed out in the description of pumps with fly wheels, must, obviously, be less economical than those which work expansively; but the enormous number of the first-named type brought into use within the last 25 years, clearly indicates the demand for cheap and reliable pumps, even if they are not strictly economical.

PUMPS FOR HOT LIQUORS.—Attention is directed to the fact, well known but not always remembered, that difficulties with suction increase in proportion with the temperature of the liquor to be pumped.

Water, or other liquid hot enough to emit vapour when not exposed to atmospheric pressure, must **flow into** and fill the pump chamber without relying on suction.

STARTING PUMPS AGAINST FULL PRESSURE.—A foot valve on the suction pipe will usually keep the pumps and pipes charged, but if difficulty in starting is experienced it may be due to defects in the connections, or to an accumulation of air in the pump chamber. The air is, however, quickly removed if the delivery pipe is provided with a check valve and waste pipe. A few strokes of the pump clear the chamber of air and (the waste pipe being closed) the pump will give the usual delivery.

It is essential that there shall be no leakage of air in the supply pipe. The check valve is required, in any case, to keep back the pressure in the delivery pipe when the pump valves require attention.

FIRE PUMPS.—It will be evident that any pumping machinery which will deliver the requisite quantity of water at a sufficiently high pressure, will be available for service in extinguishing fire, if the necessary connections and appliances are provided.

For temporary duty of this kind, the tabulated speed of working may be very largely increased, with a corresponding increase in the quantity of water delivered.

WATER BALLAST PUMPS. TANK SUPPLY PUMPS. OIL PUMPS. Whether machinery for these purposes shall be arranged horizontally or vertically and be direct acting, as illustrated in Figs. 2544 to 2552, or driven in some other manner, is purely a matter of convenience.

The duty being usually a large volume delivered against a low head, admits of the diameter of the pump, relatively with that of the engine, being larger than is permissible for pumps working against high pressures.

The valves and passages have the area required for the free passage of floating matter which must often be dealt with, and all working parts are accessible for examination and renewal.

PUMPS FOR BREWERIES, TANNERIES, GAS WORKS, SUGAR REFINERIES, etc., are as above described. Double acting pumps of this type, Figs. 2535 to 2541, Centrifugal Pumps, Pulsometers, and Steam Jet Elevators, are also largely employed.

PUMPS FOR RAISING ACIDS, ALKALINE OR CHEMICAL COMPOUNDS are specially constructed to withstand the action of compounds, the nature and strength of which have been defined.

WRECK-RAISING PUMPS.—In most cases it is sought to obtain maximum pumping capacity (against little or no head) with minimum weight of machinery and great facility for fixing it. Hence the centrifugal pump is perhaps more generally used than any other, but under some circumstances it is found desirable to use a pulsometer or a duplex or other form of reciprocating pump. Information relating to all these will be found under the respective headings. The appliances for slinging and readily handling the machinery are made to suit the tackle available.

SINKING PUMPS.—Many forms of the pumping machinery referred to are easily adapted for service in clearing mines, wells, foundations, &c. of water, but the conditions under which they are employed vary too widely to admit of all of them being illustrated.

Attention is, however, directed to the great facility afforded by compact double-acting pumps worked by steam or by electric current, the pumps being suspended or otherwise arranged to follow the sinking, and thus always work under the most favourable conditions.

The suction and delivery valves are specially designed to admit of the free passage of gritty and other foreign matter.

HAND PUMPS.—The principal features in hand power pumps are that the bucket and valve shall be, as far as possible, indestructible, and shall free themselves easily from obstructions.

An experience of half a century indicates that the valve, Fig. 2619, for small sizes (up to about 5 or 6 inches diameter), and the ordinary weighted leather flap for larger sizes, best fulfil the above-named conditions.

INFORMATION REQUIRED.—The preceding remarks indicate generally the kind of information which should be furnished if advice is desired, and this should be supplemented by (at least) the following details :—

1. A reference to the illustration or description of the installation required, or—failing that—details of the conditions under which it is to be used ; also whether low cost or highest efficiency is the important consideration.
2. The maximum duty to be rendered in a given time.
3. Drawings or sketches with figured dimensions showing the position of the pumps relatively with the suction water level, and the height from it to the point of discharge.
4. If steam is to be supplied from existing boilers, the minimum pressure available should be stated, and the distance between boilers and pumps.
5. If boilers are required, the type will be conveniently defined by reference to Section I of this Handbook, or information given with regard to fuel, difficulties relating to transport (if any), boiler setting, &c.
6. If the pumps are driven from an existing motor or shaft, the speed of the driven shaft should be stated, and the restrictions (if any) to the diameter of the pulley.
7. For provisions for pumping sewage or other semi-fluids, see remarks on “ Valves and Pumps.”

RELATIVE VALUES OF STEAM, ANIMAL, AND MANUAL POWER IN WATER LIFTED.—The subjoined figures will enable anyone to estimate the power required for raising a given quantity of water, and—by reference to the descriptions of various types of pumps given in the following pages—to determine which of the appliances are best adapted for the work to be performed.

Steam (or other motor) horse-power, as is well known, is equal to raising 33,000 lbs. to a height of 1 foot in one minute. As one Imperial gallon of water weighs 10 lbs. it follows that one horse-power will raise 3,300 gallons to a height of 1 foot, or 330 gallons to a height of 10 feet, and so on.

The power exerted by animals working 8 hours a day, is equal (approximately) to raising the undernamed quantities per minute, to a height of 1 foot.

One horse about ...	...	...	...	21,000 lbs. foot pounds
One bullock about ...	...	...	...	12,000 lbs. ”
One mule or pony ..	...	...	...	8,000 to 10,000 lbs. ”
One donkey ...	...	...	...	3,500 to 4,000 lbs. ”

Manual power naturally varies very greatly, but may be expected to range from 2,000 to 3,000 foot pounds.

The speed of working is usually from 20 to 30 revolutions of the handle per minute, the power exerted on the handle being 15 to 25 lbs.

The losses in friction in gear, pipes, &c. also vary widely, and 25 per cent. (at least) should be allowed for losses arising from these causes.

CAPACITIES OF SINGLE RECIPROCATING PUMPS.—The following table gives the approximate **theoretical** duties of single acting pumps (one barrel) up to 24 inches diameter, when working at given speeds and lengths of stroke, and furnishes the data for readily ascertaining the capacities at other speeds and lengths of stroke.

For double acting and double barrel pumps multiply the figures by two.

For treble barrel pumps multiply the figures by three.

For losses due to friction, wear of packings, etc. a deduction should be made of not less than 10 per cent.

CAPACITIES OF PUMPS IN GALLONS PER HOUR.

Length of Stroke. Strokes per minutes.	3 inches.				6 inches.			
	10	20	30	40	10	20	30	40
1-in. diam., gallons per hour ...	5	10	15	20	10	20	30	40
1½-in. " " " " ...	8	16	24	32	16	32	48	64
1½-in. " " " " ...	11	22	34	44	22	44	66	88
2-in. " " " " ...	20	40	60	80	40	80	120	160
2½-in. " " " " ...	32	64	96	128	64	128	192	256
3-in. " " " " ...	46	92	138	184	92	184	276	368
3½-in. " " " " ...	62	124	186	248	124	248	372	496
4-in. " " " " ...	81	162	243	324	162	324	486	648
4½-in. " " " " ...	103	206	309	412	206	412	618	824
5-in. " " " " ...	126	252	378	504	252	504	756	1008
6-in. " " " " ...	182	364	546	728	364	728	1092	1456
7-in. " " " " ...	249	498	747	996	498	996	1494	1992
8-in. " " " " ...	325	650	975	1300	650	1300	1950	2600
9-in. " " " " ...	412	824	1236	1648	824	1648	2472	3296
10-in. " " " " ...	509	1018	1527	2036	1018	2036	3054	4072
12-in. " " " " ...	732	1464	2196	2928	1464	2928	4392	5856
15-in. " " " " ...	1145	2290	3435	4580	2290	4580	6870	9160
18-in. " " " " ...	1645	3290	4944	6592	3290	6592	9888	13184
21-in. " " " " ...	2250	4500	6750	9000	4500	9000	13500	18000
24-in. " " " " ...	2930	5860	8790	11720	5860	11720	17580	23440

CAPACITIES OF PUMPS IN GALLONS PER HOUR (*Continued*).

Length of Stroke. Strokes per minutes.	9 inches.				12 inches.			
	10	20	30	40	10	20	30	40
1-in. diam., gallons per hour ...	15	30	45	60	20	40	60	80
1½-in. " " " " ...	24	48	72	96	32	64	96	128
1½-in. " " " " ...	33	66	99	132	44	88	132	176
2-in. " " " " ...	60	120	180	240	80	160	240	320
2½-in. " " " " ...	96	192	288	384	128	256	384	512
3-in. " " " " ...	138	276	414	552	184	368	552	736
3½-in. " " " " ...	186	372	558	744	248	496	744	992
4-in. " " " " ...	243	486	729	972	324	648	972	1296
4½-in. " " " " ...	309	618	927	1236	412	824	1236	1648
5-in. " " " " ...	378	756	1134	1512	504	1008	1512	2016
6-in. " " " " ...	546	1092	1638	2184	728	1456	2184	2912
7-in. " " " " ...	747	1494	2241	2998	996	1992	2988	3984
8-in. " " " " ...	975	1950	2925	3910	1300	2600	3900	5200
9-in. " " " " ...	1236	2472	3708	4944	1648	3296	4944	6592
10-in. " " " " ...	1527	3054	4581	6108	2036	4072	6108	8144
12-in. " " " " ...	2196	4392	6588	8784	2928	5856	8784	11712
15-in. " " " " ...	3435	6870	10305	13740	4580	9160	13740	18320
18-in. " " " " ...	4944	9888	14832	19776	6592	13184	19776	26368
21-in. " " " " ...	6750	13500	20250	27000	9000	18000	27000	36000
24-in. " " " " ...	8790	17580	26370	35160	11720	23440	35160	46880

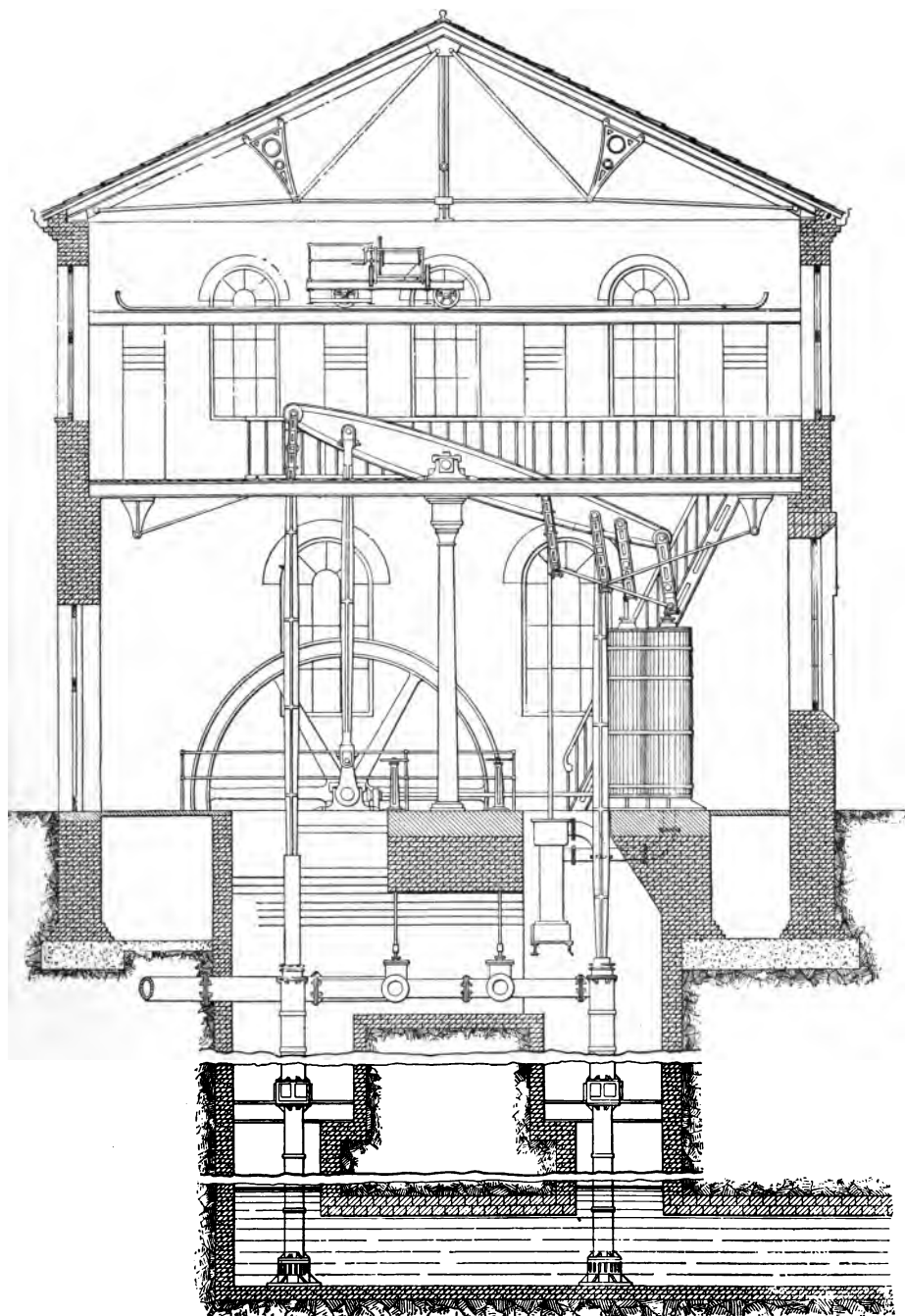


Fig. 2500.

BEAM PUMPING ENGINES.

COMPOUND CONDENSING BEAM PUMPING ENGINES.—The diagram engraving, Fig. 2,500, represents a side elevation of pumping machinery designed and built by the writer for the water service of a Colonial city. Three similar engines, varying only in the dimensions of the pumps, were subsequently supplied for three other districts of the same Colony.

The duty of the engine is 1,200,000 gallons (50,000 gallons per hour) delivered to a height of 180 feet, and 50,000 gallons per hour to the low service reservoir at a height of 37 feet.

Two of the engines above referred to deliver a smaller quantity at a greater height, but the duty in foot pounds is (practically) the same for each of the four engines.

The engines are arranged as shown in the engraving, the dimensions of the cylinders being respectively 15 by 49½ inches and 26 by 66 inches.

The beam is formed of two wrought iron plates of heavy section which are connected by distance pieces and bolts. The gudgeons are of mild steel, and are secured in bosses registered in the beam plates and rivetted to them. The parallel motions are as illustrated, the fly-wheel is 15 feet diameter, and the engine is complete with governors for speeds of 16 or 20 revolutions per minute, jet condenser, air pump, cold water and feed pumps, copper pipes between cylinders, pressure and vacuum gauges, indicator cocks and all accessories.

The pumps are of the ram and bucket type, and are respectively of 16 inches and 11 inches diameter, complete with double-beat suction valves, bye pass from barrels to suction pipe, air vessel on delivery main, sluice valve, relief valve on rising main for pressures of 90 to 150 lbs. per square inch, snifting valves, &c.

The dimensions of the pumps for the other three engines are in proportion with the duty they perform, but the arrangement of machinery is unaltered.

The boilers are of the Lancashire type, illustrated by Fig. 1521 (Section I.) and are tested by hydraulic pressure to 150 lbs. per square inch, the working pressure of steam being 80 lbs. Two boilers are provided for each set of pumping machinery, one being usually in reserve. The materials are of the high quality required for such boilers, all flanging and rivetting is done by machine, and the fittings include one dead weight and one spring safety valve, dial steam pressure gauge, with copper pipe and cock, all steam fittings, feed water retention valve, gun-metal scum and blow-off cocks, furnace mountings, etc.

The pipes to connect with the engines have faced flanges, steam stop valve, expansion joint, and the accessories usual in the best practice.

Overhead travelling crane.—For convenience in erection and maintenance, an overhead hand-power travelling crane, equal to a working load of 4 tons, of the type Fig. 2270 (Section II.) spans the engine room and commands the whole of the area of floor. White ants abound and the beams carrying the longitudinal rails are also of wrought iron; timber is usually adopted elsewhere.

The engine room equipment comprises steam and vacuum gauges, water pressure recorder, counter to register up to 10,000,000, a Richard's Indicator, cocks, diagram papers and accessories. The Fitter's tools include vice bench and vice, stocks, taps and dies, pipe cutter, tongs, shifting and ordinary spanners, ratchet braces and drills, and a supply of hammers, chisels, files, spirit level, screw plates and small tools, white lead, spun yarn, wipings, etc.

The duplicate parts include one high and one low pressure cylinder with cover and bolts, piston and rod complete to suit any of the four engines.

Each of the four pumping stations are provided with duplicate bucket and suction valves, also a set of valve rods, spare fire bars, gauge glasses and rings and similar small fittings, stoking tools, etc.

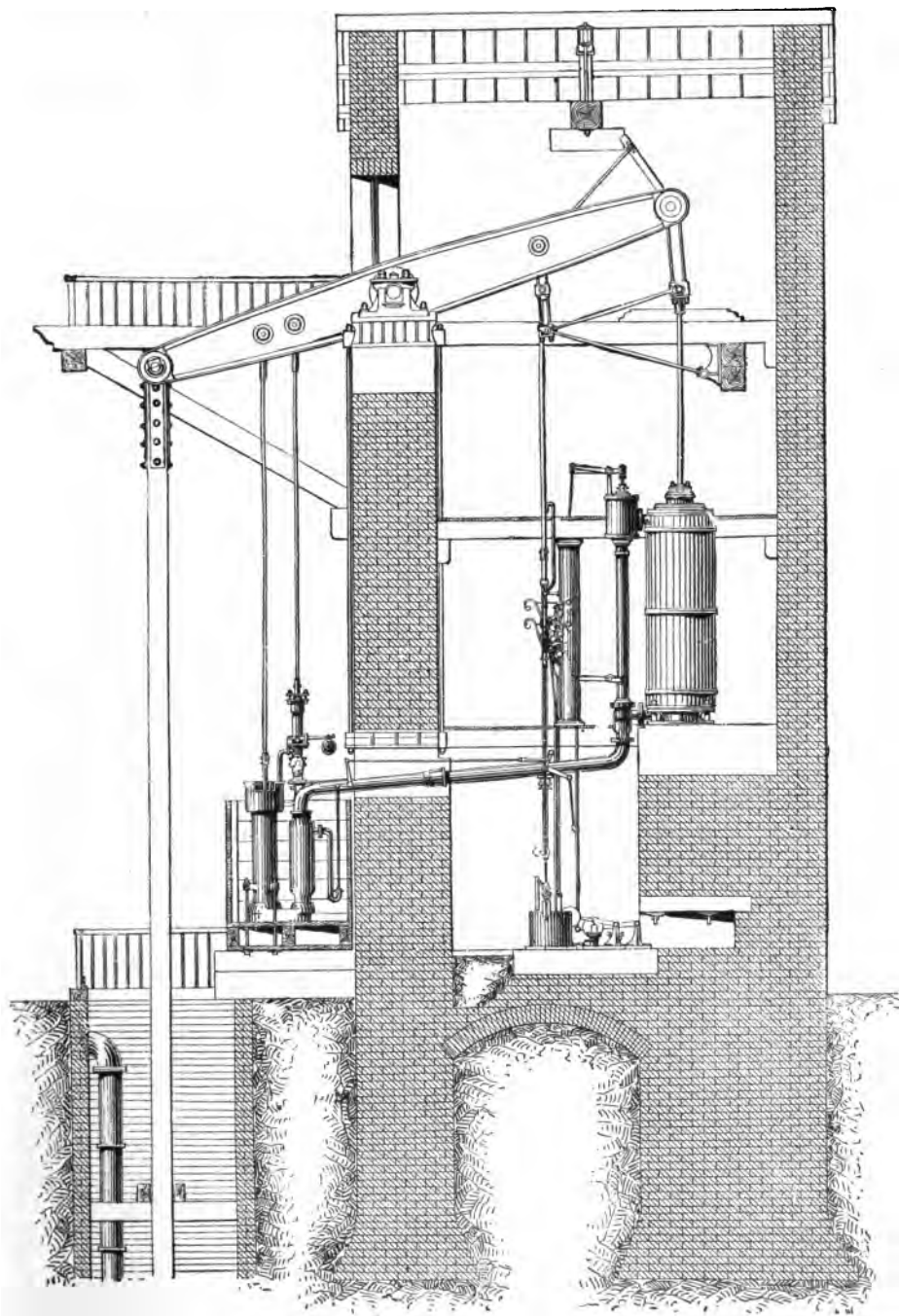


Fig. 2501.

CORNISH PUMPING ENGINES.—Fig. 2501 represents an engine of the under-named dimensions, built by the Author's firm about 25 years ago, for draining a Silver Mine in Chile.

This engine is still at work, and the Consulting Engineer, reporting to the owners of the mine (on the 16th March, 1896) with reference to this engine and a 16 inch double cylinder direct winding engine of the type Fig. 2283 (Section II.), writes as follows :

"During the 23 years these engines have been performing the work demanded by the constant operations of the mine, no structural alterations, nor repairs of any importance have been done to them. The spare pieces of wearing parts, with which they were from the first liberally provided, have sufficed to keep them running up to date."

The report concludes with remarks complimentary to the builders, which need not here be quoted.

The steam cylinder is 20 inches internal diameter, the stroke is 7 feet, and the walls and covers are steam jacketed, the piston and junk rings are of cast iron with metallic rings and springs; the piston rod is tapered and cottered respectively to the piston and crosshead. The cylinder jacket is felted and covered with mahogany secured by brass strips, etc.

The valve gear is adjustable to cut off steam at the point required for raising a larger or smaller quantity of water under the most economical conditions, as is usual in engines of this description.

The parallel motions are of the usual form, the rods are made of wrought iron and the moving ends are fitted with hard gun metal bearings and cotters for taking up wear.

The beam is formed of two wrought iron plates of ample section with distance pieces and bolts. The beam gudgeons and those for the steam cylinder and pumps are of wrought iron, carried in bosses which are rivetted to the beam plates. The pump and steam cylinder gudgeons are respectively 10 feet 4 inches and 12 feet from the centre of the main gudgeons, so that the pump has a stroke of 6 feet and steam piston 7 feet.

The pumps are of the Cornish type; the suction rising mains were cast iron, but in more modern practice they have been in steel which if of equal strength are about one fifth the weight.

The air and feed pumps are of the usual type and are driven from the beam, as indicated in the engraving.

Steam pipes.—The flanged pipe connections are coated with non-conducting material to prevent undue condensation.

The boilers are of the Cornish type, 30 feet long and 6 feet diameter as illustrated by Fig. 1522 (Section I.) Three boilers are provided, but one was always in reserve, two only being required to work the pumping engine and a pair of winding engines similar to Fig. 2283. (Section II), ore breakers, etc. which were supplied for this mine.

The price of a Cornish pumping engine, as above described, with 50 fathoms (300 feet) of pump pipes, spears, etc. but not including boilers, is about £1000

The approximate weight is 30 tons.

DIRECT ACTING HIGH SERVICE PUMPING ENGINES.

DIRECT ACTING PUMPING ENGINES.—Space does not admit of illustration of numerous arrangements of pumping machinery for high and low lifts employed for raising water for town service, but Figs. 2502 to 2504 represent the types of triple expansion, compound and high pressure engines in general use, the first named being unquestionably the most economical and perfect system.

ADVANTAGES OF DIRECT ACTING ENGINES.—The power due to the pressure of steam is transmitted direct to the pump or plunger without the intervention of a beam or gear, and the cost is less than that for a beam pumping engine of equal capacity; the cost of maintenance is lower, and there is a large saving in the outlay for buildings and foundations.

RELATIVE ECONOMY OF EACH TYPE.—The data given in the remarks on Prime Movers (see pages 1 to 4 of Section I) applies equally to pumping engines and the following examples, from actual results, clearly indicate the relative economy of the different systems when working under equal conditions as regards quantity and height of lift.

A triple expansion engine consumes about 15 per cent. less coal than a double cylinder side by side, (or a tandem) compound engine, and about 50 per cent. less than a single cylinder high pressure, of equal capacity.

A compound engine raising 124½ million foot pounds consumes 390 tons less coal per annum than a high pressure engine alongside it performing precisely the same duty.

Exceptional conditions.—The foregoing figures point to the conclusion that where large quantities of water must be raised continuously, and the highest economy in cost of working is of higher importance than initial outlay, preference should be given to the most perfect, although not the least costly machinery.

There are, however, many conditions, some of which are referred to elsewhere, which render it desirable to limit the outlay for a pumping plant, pending the natural development and corresponding improvement in the financial position of the district to be served.

Information required.—The cost of direct acting pumping engines cannot be defined without accurate details of the quantity to be raised in a given time, the depth of well, height of delivery, length and diameters of mains (if existing), and general information on local conditions (see also page 4).

TRIPLE EXPANSION PUMPING ENGINES.—The economy in coal consumption attained by the use of triple expansion marine engines has led to the adoption of this system for raising water, and Figs. 2502 and 2503 respectively represent front and side elevations of a typical arrangement of triple expansion pumping engines, capable of raising 500,000 gallons per 24 hours to a height of 250 feet when making 33 strokes per minute. The leading dimensions are :

Diameter of high pressure cylinder	...	...	15½ inches
" intermediate	"	...	24 "
" low pressure	"	...	42 "
" of pump plungers	...	...	48 "
Length of stroke	...	...	16 "

The large saving in fuel (15 to 50 per cent.) above referred to is due to the use of higher initial pressure of steam, much higher grades of expansion (usually 15 to 16 times), and more uniform temperatures in the cylinders. There is absolutely no drawback in respect of permanent efficiency or cost of maintenance.

For low lifts the dimensions of the pumps are increased to the extent necessary for the larger quantity of water to be delivered.

STANDARD DIMENSIONS OF TRIPLE EXPANSION PUMPING ENGINES.—One or other of the undernamed will probably be found to fulfil most conditions where the total lift does not exceed about 250 feet. But there is, practically, no limit to the proportions of engines and pumps to adapt them to the performance of any given duty.

Capacity, million gallons per 24 hours	...	½	¾	1	1½	2	2½
Horse power in water raised	...	26·3	39·4	52·6	79	105	131
Diameter of high pressure cylinder	inches	6	6½	7½	9	10	11
" intermediate	"	8½	10½	11½	14	15½	17½
" low	"	15	18	20	24	27	30
" pump	...	5½	7½	7½	9½	10½	11½
Length of stroke	...	24	24	30	30	36	36
Strokes per minute	...	50	50	45	45	42	42

DIMENSIONS (Continued).

Capacity, million gallons per 24 hours	...	3	4	5	6	8	10
Horse power in water raised	...	158	210	263	316	421	526
Diameter of high pressure, cylinder inches	...	12½	13½	15½	17	18½	21
" intermediate	"	19	21½	24	26½	29½	33
" low	"	33	37	42	46	51	57
" pump	...	12½	14½	16	17½	20	22½
Length of stroke	...	36	48	48	48	60	60
Strokes per minute	...	42	33	33	33	27	27

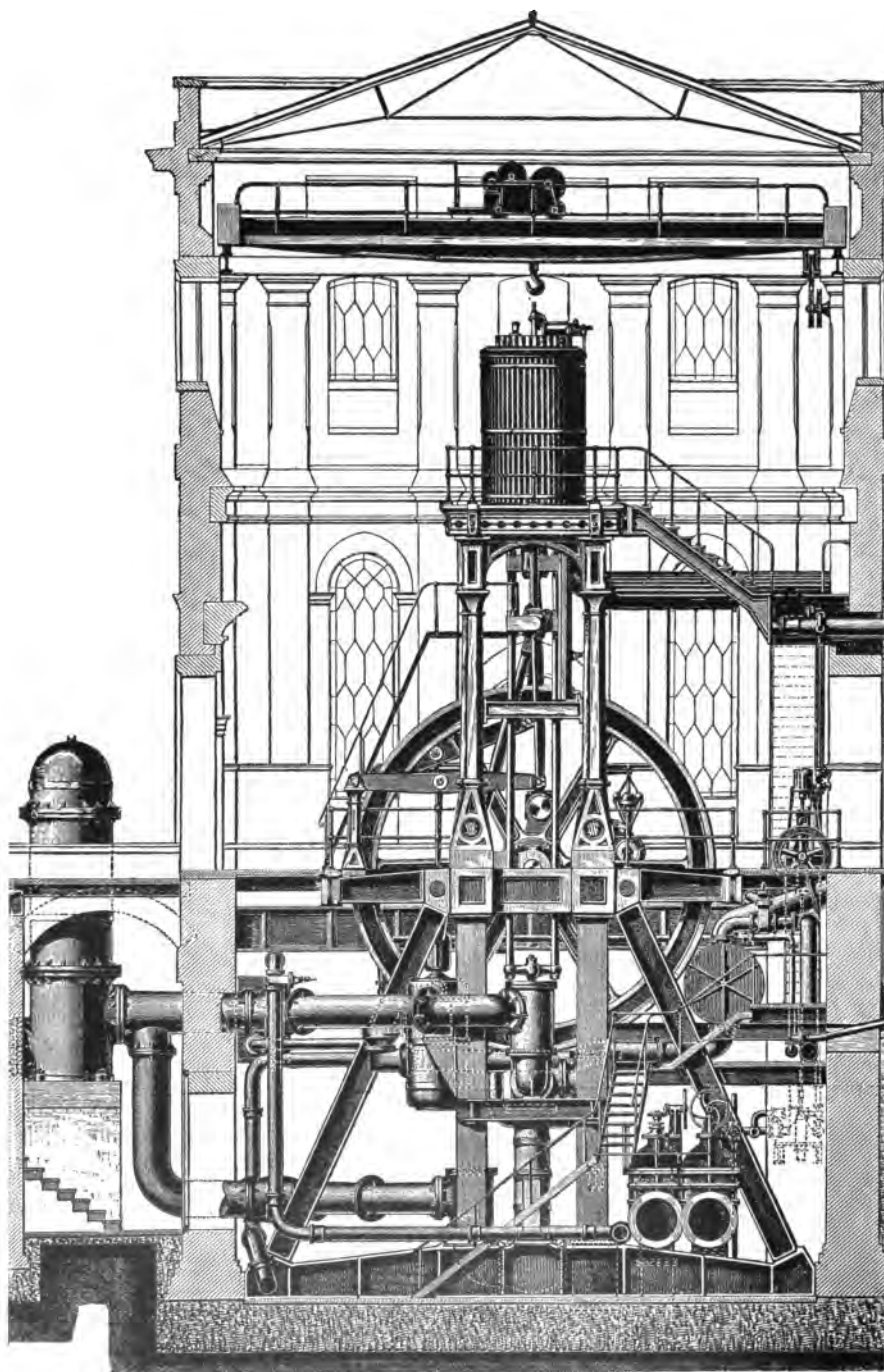


Fig. 2504.

The outline specification for engines of all proportions is as follows :

The cylinders are steam jacketed in the most approved manner in body and covers ; each cylinder is carried on a cast iron standard of box section and supported in front by a steel column. The three standards and columns are secured to the bed plate which is bolted to the four girders as shown, one under each crank shaft journal. The liners of cylinders are of special metal and the pistons, valves, etc. are of the best construction.

The crank shaft, cross-heads and connecting rods are of mild steel, the guide slipper has ample wearing surface and is adjustable, with provision for ample lubrication. The fly wheel is turned to run true and has bright wrought iron hoops around the centre boss.

The surface condenser is of the Marine type with brass tube plates and tubes, doors in ends for examination, open stand pipes for escape of air, etc. and is fixed on the line of suction pipe to the pumps. The whole of the water pumped passes through the condenser and the increase in temperature does not exceed 2°. The vacuum is within 2 inches of the barometer.

The air pump is single acting and is worked from the end of the crank shaft, as shown.

The main pumps are directly below their respective cylinders and are single acting rams with external packings and each pump has an independent valve box and valve for suction and delivery. The pump valves are of the four beat type which give a clear water way, and doors are provided to give access to each valve.

The air vessel is of proportions suitable for the duty of the pumps and is complete with retention valve on the inlet pipe, gauge glass and mountings to indicate the space for air in the vessel, air charging pumps, etc.

COMPOUND AND CONDENSING DIRECT-ACTING PUMPING ENGINES.—Fig. 2504 illustrates the end elevation of an engine room in which are fixed two pairs of compound condensing pumping engines. Collectively of 1300 effective horse-power which deliver about 18 millions of gallons per 24 hours against a head of 280 feet.

The mean consumption of coal during 14 days (of 24 hours) continuous working was 1.81 lbs. per horse power in water lifted, and 1.54 per indicated horse power without economiser of the type referred to at page 48 of Section I. If this had been used the result would have been about 10 per cent. better.

The high-pressure cylinder is behind the low pressure cylinder and is not seen in the engraving. The pumps are immediately below them, as illustrated.

The working parts, surface condenser, etc. are (substantially) as last described, and are so clearly indicated in the engraving that detailed description will be unnecessary.

The air vessels—one to each pair of pumps—are fixed outside the engine room. They are tested to a pressure equal to a head of 750 feet, and are provided with retention valves, gauge fittings, relief valves on the delivery sides, emptying valves, and all accessories.

Overhead travelling crane.—In addition to the usual equipment of engine room tools and instruments, this installation was complete with an overhead travelling crane of 15 tons power.

This accessory is now almost universally provided in connection with pumping and electric lighting stations with the object of saving much time in erection and affording facilities in the maintenance of the machinery.

Cranes for this and similar purposes are illustrated and described at pages 106 to 125 of Section II.

Boilers.—Steam is supplied from a range of six double-flued Lancashire boilers of the type indicated in Fig. 1521 (Section I.) ; ordinarily any four of the boilers are in use, leaving two always in reserve.

The boilers are built of mild steel and are tested by hydraulic pressure to 175 lbs. per square inch, the working pressure being 100 lbs. per square inch.

The Furnace—Steam and feed water fittings are as used in the best practice. The main steam pipes have expansion joints and copper bends. Copper pipes conduct the water condensed in the steam jackets to the boilers, and the feed water pipes are arranged for circulation through the economisers, or direct to the boiler, as desired.

HIGH PRESSURE DIRECT-ACTING PUMPING ENGINES.—The general arrangement so closely resembles that indicated in Fig. 2504, that further illustration and description will be unnecessary.

It may, however, be well to mention that when the pumping power of high pressure engines becomes inadequate for the large increase in population which an efficient waterworks supply invariably attracts, the power can be doubled by compounding the engines and putting in corresponding pumps.

This has been done in many cases with entirely satisfactory results in economy and increase in duty, and with a relatively small outlay of capital.

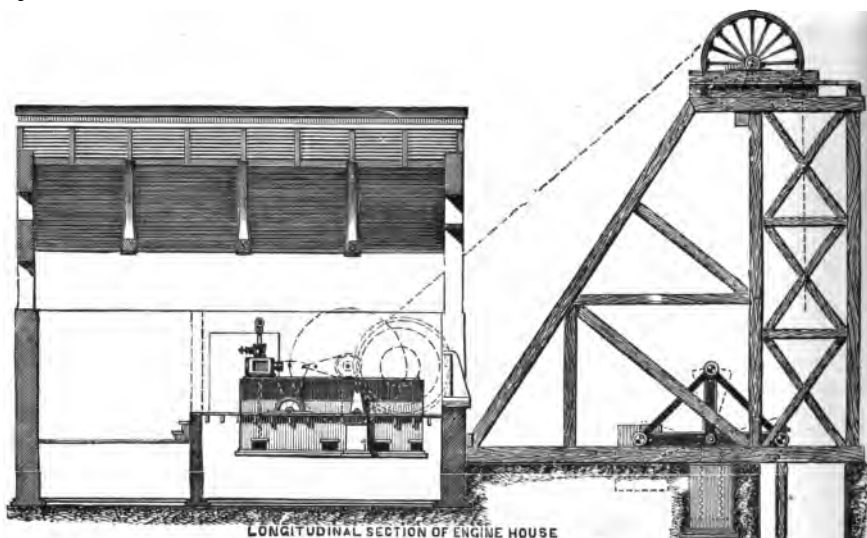


Fig. 2506.

MINE PUMPS, whether worked by engine direct from the surface or by Quadrant arm, are generally arranged as indicated in Fig. 2506, which represents a drawing lift 8 inches diameter, and a forcing lift 10 inches, the total depth being about 280 feet.

The working barrel is of the usual Cornish type, with door piece for access to the valve and valve seat. The pipes are of cast iron, with faced flanges, but they can be made in steel if desired.

The approximate prices given below include the spears, cast iron pipes, pumps, bolts, etc. up to the surface. The cost of Mine Pumps of other proportions can be ascertained approximately by reference to the items mentioned further on (see Index). But really reliable estimates cannot be made without information as to the quantity of water to be raised in a given time, height of lift, etc. (see page 4).

PRICES OF MINE PUMPS, 4 inches Diameter by 3ft.

Total depth	...	feet	200	300	400	500
Price of Pumps	...	...	£76	£92	£102	£137

PRICES OF MINE PUMPS, 6 inches Diameter by 3ft. 6in.

Total depth	...	feet	200	300	400	500
Price of Pumps	...	...	£105	£132	£158	£193

PRICES OF MINE PUMPS, 8 inches Diameter by 4ft.

Total depth	...	feet	200	300	400	500
Price of Pumps	...	...	£142	£188	£218	£260

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

SIDE ELEVATION

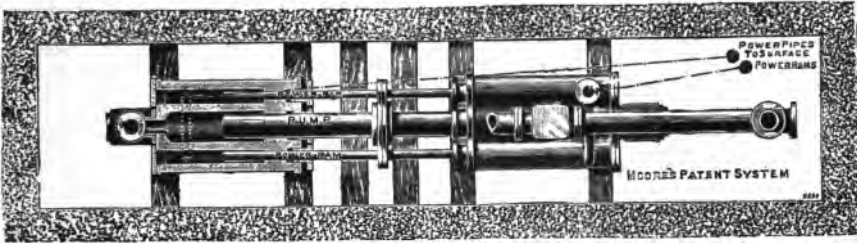


Fig. 2507.

DUPLEX HYDRAULIC MINE PUMPS.—Fig. 2507 illustrates a useful and perfectly reliable arrangement of pumping plant devised by Mr. Moore for working mine pumps in any position relatively with the drawing or pump shaft. For this purpose, hydraulic power, which can be conveyed in any direction, however tortuous, is substituted for the reciprocating rods or “spears” ordinarily used.

Pumps of this construction are in successful operation from 4 inches diameter and 3 feet stroke, which deliver about 3000 feet horizontally and 420 feet vertically, to 14 inches diameter and 5 feet stroke, forcing through a length of 1800 feet with a vertical lift of 600 feet; but the dimensions are varied indefinitely to suit the conditions to be fulfilled.

The hydraulic power is generated by a pair of pumps driven by belt, or by steam directly as shown in Figs. 2508 or 2509. These pumps, usually fixed at the surface, transmit pressure through fixed pipes of small diameter to a pair of ram pumps below, which raise the water to the surface in a single lift.

The mine pump consists of a pair of ram pumps which are connected by pipes with the hydraulic pumps driven by steam or other power, as above described. It may be fixed horizontally or in any other convenient position, and is quite as efficient in places where pumps of the ordinary construction cannot be used as the latter are when fixed in a shaft and worked by spears.

One or more mine pumps can be worked by one set of pressure pumps. There are no moving parts, guides, &c. in the shaft, and, obviously, no inconvenience from exhaust steam or radiation of heat.

The following prices include a set of pressure pumps at the surface ready for coupling to an existing engine, and the duplex mine pumps with valves and branches for connection with the pressure pipes and delivery main; but they do not include a boiler or any pipe connections between the surface and mine pumps. If no driving power is available, an independent steam pump of the types Fig. 2508 or 2509 may be more convenient than the belt-driven hydraulic pumps above mentioned.

The cost of pipes, steam pumps, &c. will be found under the respective headings, and these—with subjoined approximate prices—provide the data for estimating the cost of an installation nearly enough for most purposes.

The details required in estimating the cost of hydraulic mine pumps are:—

The depth vertically from the surface to the mine pump.

The distance horizontally from the surface to the mine pump.

The quantity of water to be raised in a given time.

The engine power or pressure of steam (if any) available.

If electric or other motor is used, the speed of driving shaft should be stated in revolutions per minute.

PRICES OF DUPLEX HYDRAULIC MINE PUMPS, Fig. 2507.

Diameter of pumps	inches	4	6	7	8	10	12	14
Length of stroke	... feet	3	3	3	4	4	4	5
Price of pumps	... ..	£115	£175	£230	£297	£345	£400	£625

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

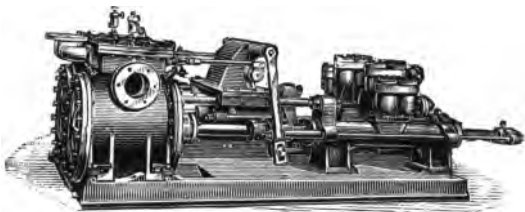


Fig. 2508.

HYDRAULIC OR DEEP LIFT (MINING) DUPLEX PUMPS.

Fig. 2508 illustrates a pair of pumps to work with the low effective steam pressure relatively with the load on the pump which is required for forcing to a great height in a single lift, as in mining and other operations, supplying hydraulic pressure for lifts, pumps, &c.

The engines and pumps are operated in the same manner as Figs. 2550 and 2551, the proportions being arranged to suit the special duty to be performed. This should be clearly defined, more especially the steam pressure at the cylinder, if steam is supplied from an existing boiler, the volume to be raised in a given time, and the total height of lift.

The pump rams are arranged to maintain an equal pressure at each end of the stroke, and are packed externally. The valve seats are adapted for passing gritty water, and all facilities are afforded for access to them.

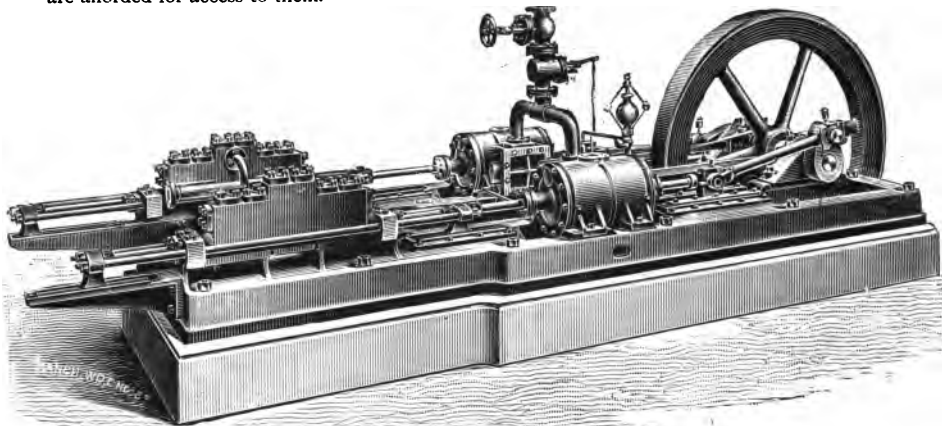


Fig. 2509.

HYDRAULIC PRESSURE PUMPING ENGINES are constructed of various types, and with widely differing proportions of engines and pump rams, but the engraving, Fig. 2509, represents a standard design of machinery which develops the maximum speed when working at pressures up to 3 tons per square inch, and delivers direct or through an accumulator, for supplying power to hydraulic cranes, (see pages 58 to 69 of Section II.), to hydraulic tools such as those referred to at pages 73 to 84 of Section IV., or to hydraulic presses and other machines for which continuous high pressure service is required.

The engines and pumps are fixed on a strong bed-plate of box section as indicated in the engraving. The steam cylinders are felted and covered with sheet steel to reduce radiation of heat, and are fitted with sight feed lubricators, steam stop valve, &c. The cross head, connecting rod, and crank shaft bearings are of gun-metal and adjustable for wear, and the crank shaft is of mild steel.

The pump barrels are of forged cast-steel bored out of the solid for pump chamber, passages, and valve boxes. The rams are of phosphor bronze packed externally and supported by cross heads at each end. The valves are arranged to afford complete facility for examination and efficient maintenance.

The material and workmanship are of the high character essential for machinery which is continuously employed under the well-known severe conditions these engines have to fulfil.

The cost of hydraulic-power pumping engines cannot be defined without details of the work to be performed, and especially:

The maximum working pressure of pumps and the quantity they must deliver in a given time; also the pressure of steam at cylinders (if any) at disposal.

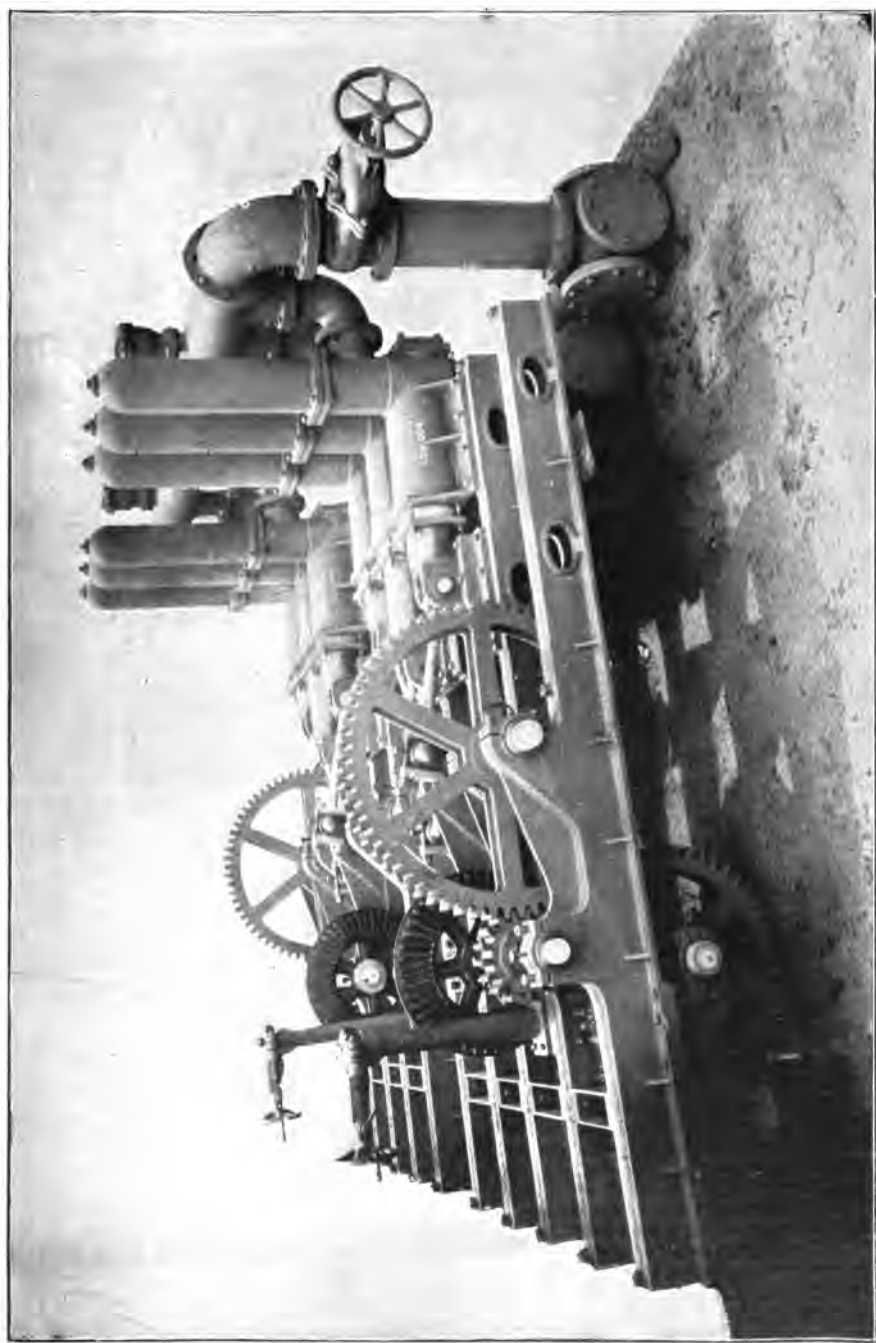


Fig. 2510.

HORIZONTAL TREBLE BARREL PUMPS DRIVEN BY TURBINES.—

The engraving, Fig. 2510, illustrates the pumps, and the diagram, Fig. 2511, the arrangement of pumps and turbines which supply an Indian City with 1,300,000 gallons of pure water per day. The height of delivery is 240 feet above the pumps, and the length of rising main is about 8,400 feet.

But the plant is arranged to be capable of eventually increasing the supply up to two million gallons per day, or 20 gallons per head per day for 100,000 consumers.

The pumps occupy a floor space of about 20 feet by 17 feet 6 inches; they work at a speed of 25 strokes per minute and were tested before shipment to double their working pressure.

An **exceptionally economical feature** in this installation is, that the pumps take their supply from the head water which provides power for driving the turbines.

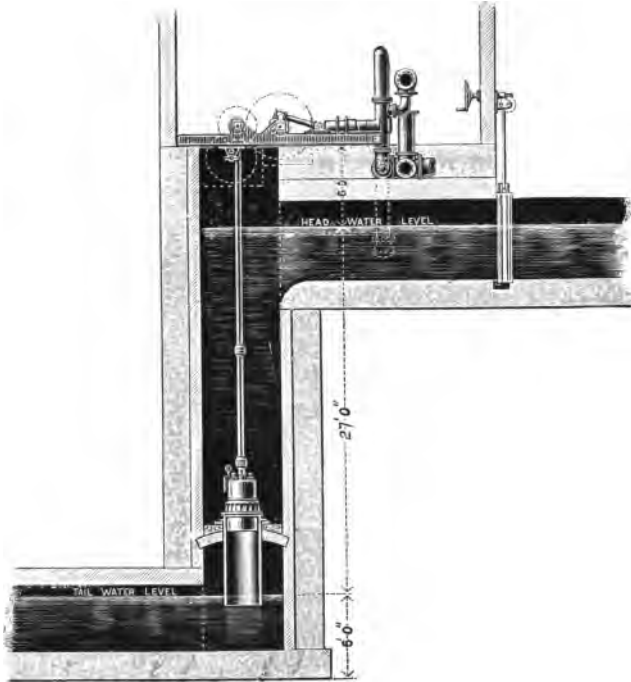


Fig. 2511.

The arrangement of the machinery is indicated in the diagram, Fig. 2511, and consists of two sets of treble barrel pumps, each set driven by a separate turbine. Provision is made for working either pump by either turbine so that, in case of accident to one set of pumping plant, there shall be no cessation in supply.

Treble barrel pumps.—The plungers are gun-metal and the barrels cast iron, each fitted with separate valve chest and air vessels. The suction and delivery valves are of hard gun-metal and doors are provided for access to them without interfering with any pipes. The three valve chambers are connected to an air-vessel outside the pump room (not shown in the engravings) with flange joint for connection to the delivery main.

The three throw crank-shaft is of mild steel with adjustable gun-metal bearings for each crank, the pinions are of malleable iron and the wheels have hard wood teeth, pitched and trimmed.

The pumps and gear for regulating the flow of water to the turbines are carried on strongly ribbed girders of box section and tied together to form a rigid base, with ample surface for bedding on concrete foundations.

The turbines are of the "Hercules" type (referred to at page 84 of Section I of this series) each of 60 brake horse power when passing 1600 cubic feet of water per minute with 27 feet fall, the bottom of the discharge pipe being immersed in the tail race as indicated in the diagram.

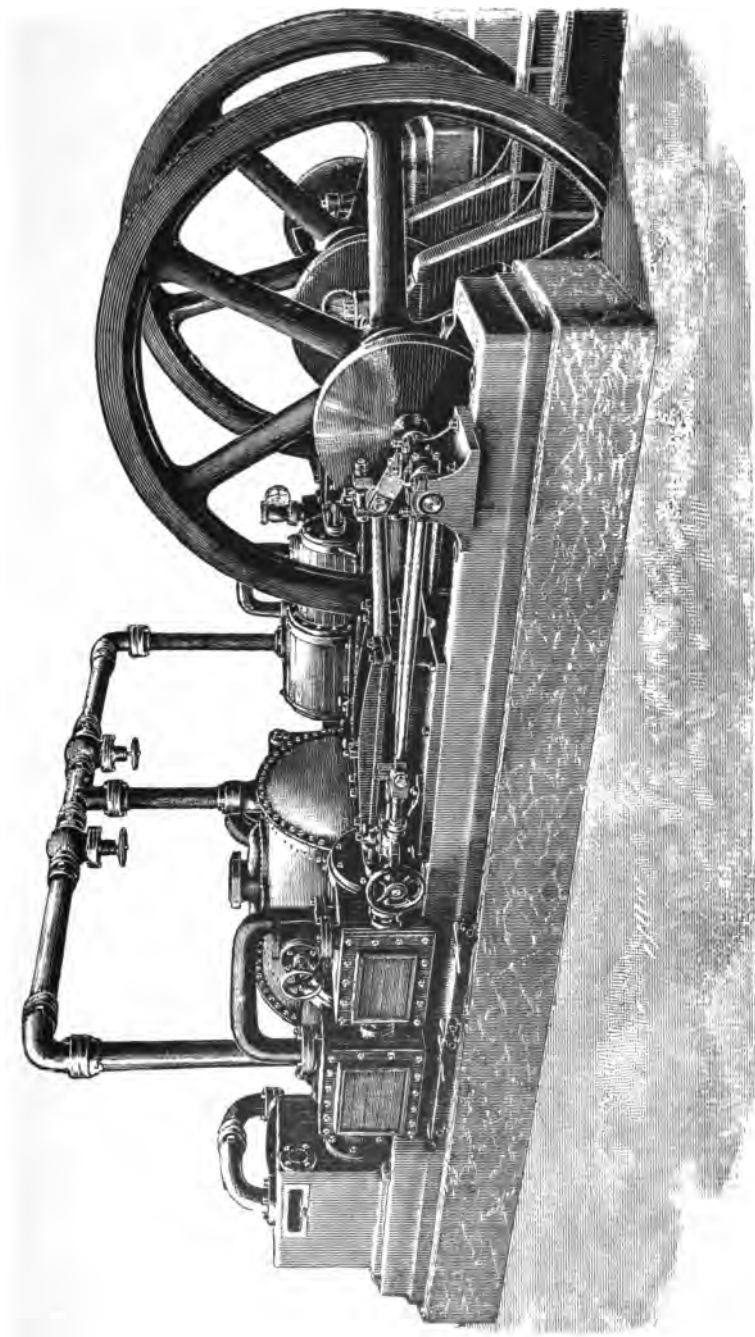


Fig. 2512.

HORIZONTAL AND GEARED PUMPING ENGINES.

Bevil gear on the top of the turbine spindle transmits power to the second motion gear on the pump and the appliances for working either set of pumps from either turbine are under the pump girders.

The spindle from the gate is carried up to the pump room floor and the flow of water to each of the turbines is regulated by the hand wheel and screw shown in Fig. 2510.

The cost of the two sets of pumps and turbines with the pipes, strainers, valves, etc. inside the pump room is about £1100

The total weight is nearly 40 tons and the cost of packing for shipment and delivery f.o.b. is about 5 per cent.

TREBLE BARREL PUMPS DRIVEN BY ELECTRIC MOTOR, BELT, ROPE, etc. (see Figs. 2530 to 2533).

HORIZONTAL COMPOUND SURFACE CONDENSING PUMPING ENGINES for town supply. Fig. 2512 is a pair of pumping engines which provide the water supply for a population of about 32,000.

The machinery consists of two horizontal tandem compound engines, with air pumps and surface condenser, two ram and bucket pumps, either pump capable of being worked by either engine, air vessel and connections, and two Cornish boilers with feed pumps and the usual connections and fittings.

Engines.—The high pressure cylinders are 9½ inches diameter, and the low pressure cylinders—fixed behind them—are 18 inches diameter, the stroke of both being 24 inches.

The slide valves are driven by an overhung crank from the end of the main crank pin, and steam is admitted to the high pressure by a "Meyer's" expansion gear which is adjusted by hand wheel, whilst the engine is running, to give any desired grade of expansion.

The air pumps are double acting, 4 inches diameter and 24 inches stroke, fixed behind the low pressure cylinder, and driven by a rod coupled to the low pressure piston.

The surface condenser has ample cooling surface for both engines, and is fixed between them. The whole of the water raised by the pumps circulates through the condenser casing on its way to the supply main, and connection with this main provides the condensing water required on starting the engines.

The pumps are of the ram and bucket type, and each pump is capable of raising 250 gallons per minute against a column of 380 feet.

They are fixed at about 50 feet below the surface, and are driven direct from the engine shafts by crank pins in the massive disc plates; the disc plates overhang the well, and have appliances for varying the length of stroke, and for working either pump from either engine. These arrangements, in conjunction with the above-mentioned expansion valve gear, provide for all contingencies and for distinct economy in coal consumption.

The buckets and valves are of the double beat type, and the pumps deliver into a rising main of 10 inches internal diameter.

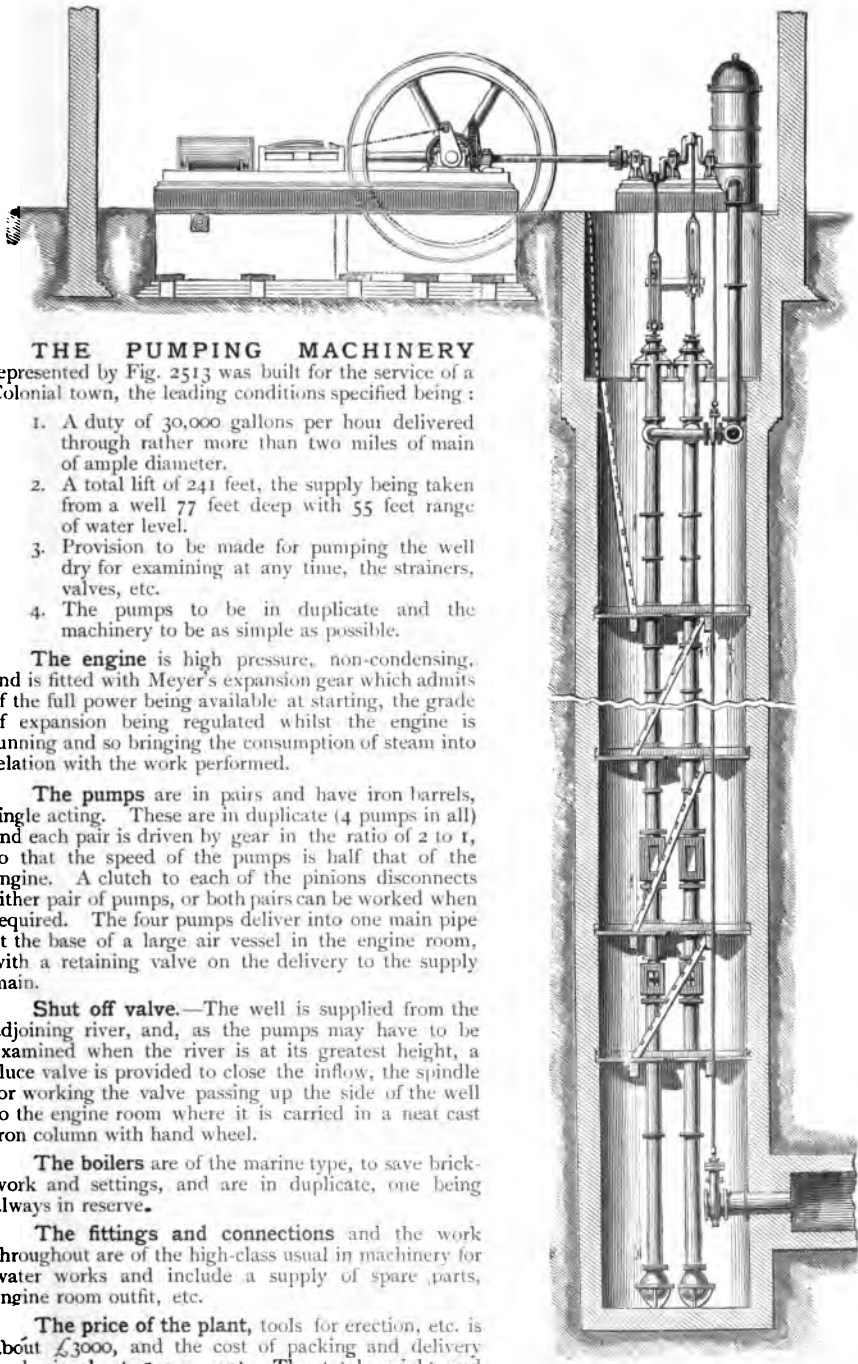
The air vessel (not shown in the engraving) is outside the engine room. The water mains are similar to those used in high pressure hydraulic service.

Boilers.—Steam is supplied from two boilers of the well-known Cornish type, illustrated at page 1522, of Section I. They are built of mild steel, the edges of all plates are planed, holes drilled, longitudinal seams double rivetted, etc., and constructed and tested for a working pressure of 80 lbs. per square inch. The boilers are fed by a Duplex pump similar to Fig. 2550, and a connection is made with the service main for washing out, refilling or, in case of need, for feed purposes.

The approximate cost of machinery, similar to that illustrated and described, exclusive of the service mains, is £2500

The approximate weight is 70 tons, and the cost of packing for shipment and delivery f.o.b. is about 5 per cent.

ROTARY HORIZONTAL PUMPING ENGINES.—Figs. 2513 to 2515, illustrate types which are doing good service under the conditions for which they were respectively designed. The prices are intended to serve as a guide in estimating the approximate cost of plant generally similar in capacity and design, leaving the final estimate for arrangement with the constructors.



THE PUMPING MACHINERY represented by Fig. 2513 was built for the service of a Colonial town, the leading conditions specified being :

1. A duty of 30,000 gallons per hour delivered through rather more than two miles of main of ample diameter.
2. A total lift of 241 feet, the supply being taken from a well 77 feet deep with 55 feet range of water level.
3. Provision to be made for pumping the well dry for examining at any time, the strainers, valves, etc.
4. The pumps to be in duplicate and the machinery to be as simple as possible.

The engine is high pressure, non-condensing, and is fitted with Meyer's expansion gear which admits of the full power being available at starting, the grade of expansion being regulated whilst the engine is running and so bringing the consumption of steam into relation with the work performed.

The pumps are in pairs and have iron barrels, single acting. These are in duplicate (4 pumps in all) and each pair is driven by gear in the ratio of 2 to 1, so that the speed of the pumps is half that of the engine. A clutch to each of the pinions disconnects either pair of pumps, or both pairs can be worked when required. The four pumps deliver into one main pipe at the base of a large air vessel in the engine room, with a retaining valve on the delivery to the supply main.

Shut off valve.—The well is supplied from the adjoining river, and, as the pumps may have to be examined when the river is at its greatest height, a sluice valve is provided to close the inflow, the spindle for working the valve passing up the side of the well to the engine room where it is carried in a neat cast iron column with hand wheel.

The boilers are of the marine type, to save brick-work and settings, and are in duplicate, one being always in reserve.

The fittings and connections and the work throughout are of the high-class usual in machinery for water works and include a supply of spare parts, engine room outfit, etc.

The price of the plant, tools for erection, etc. is about £3000, and the cost of packing and delivery f.o.b. is about 5 per cent. The total weight and measurement is about 130 tons.

Fig 2513.

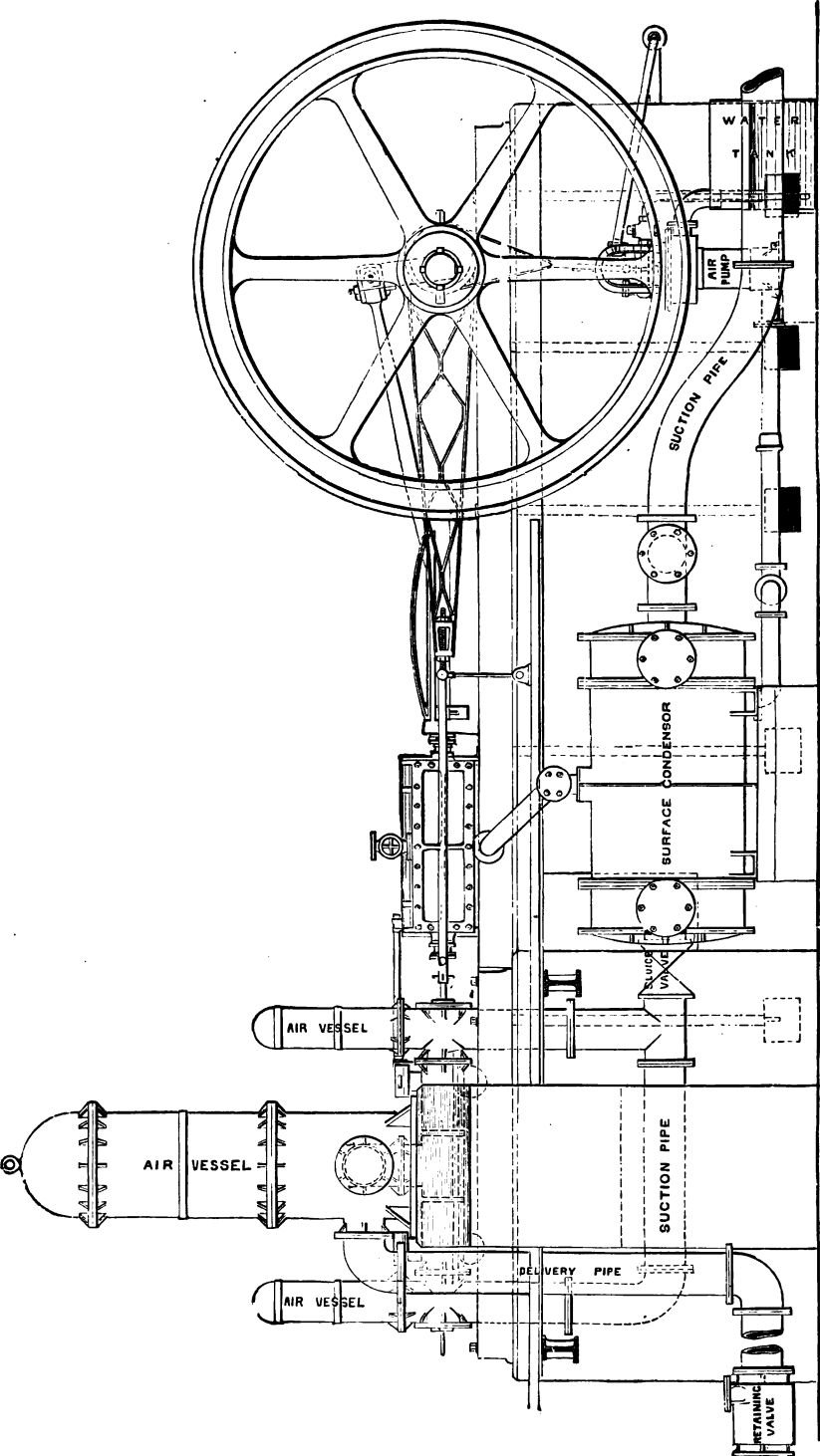


Fig. 2514.

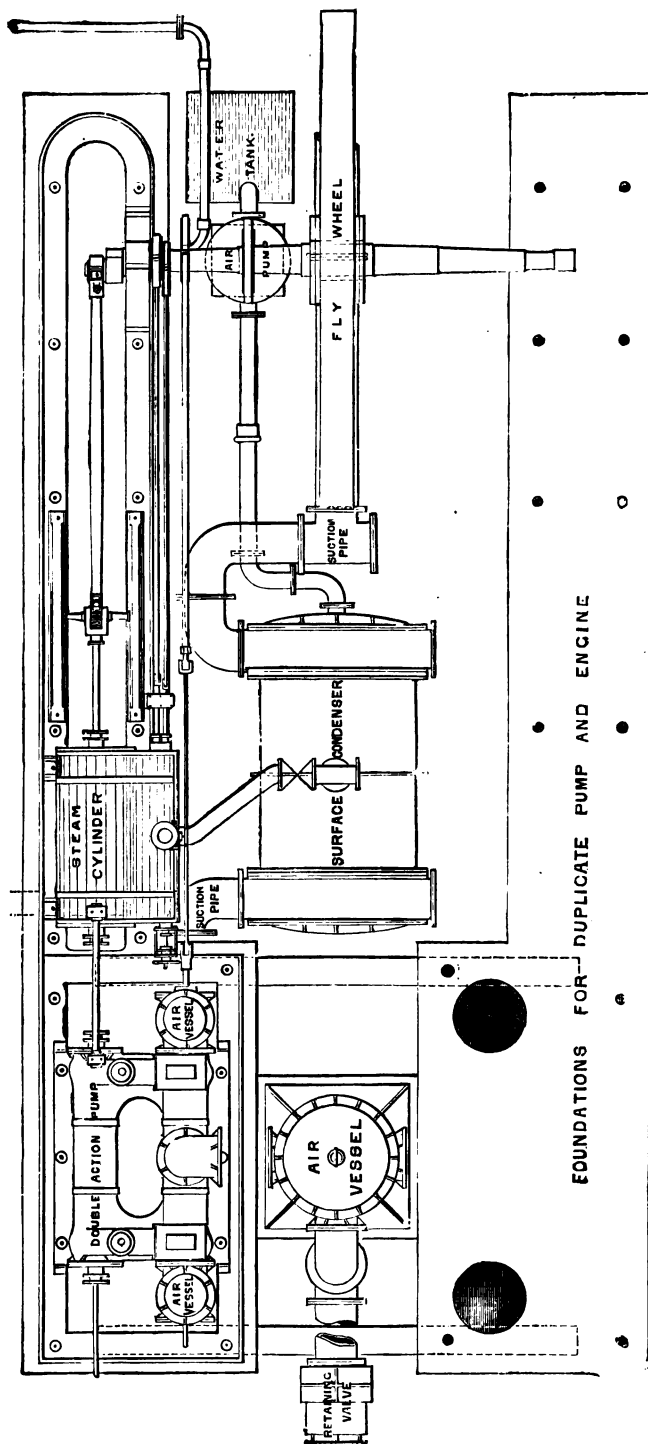


Fig. 2515.

HORIZONTAL PUMPING ENGINE WITH SURFACE CONDENSER.—

The diagram engravings Figs. 2514 and 2515 represent a plan and sectional elevation of pumping machinery for town supply, to deliver 70,000 gallons per hour to a height of 170 feet, and is typical of many other installations of various capacities which have been built by the writer's firm.

The water supply is obtained from a river, the level of which is about 5 feet below that of the engine room floor.

The machinery consists of a horizontal high-pressure engine with surface condenser, through which the water passes to the pumps.

The engine has a steam cylinder 20 inches diameter and 48 inch stroke, steam jacketed and felted and lagged to prevent loss of heat by radiation, and fitted with an adjustable expansion valve. Provision is made for admitting full steam when the engine is started against the column of water in the rising main, and for automatically shutting off steam in case of accident to the delivery main.

The main pump directly behind the steam cylinder is double-acting, and is worked by an extension of the piston rod. The valves are in equilibrium, and operated by an eccentric on the crank shaft. The air vessels and the retaining valve on the delivery side are arranged as indicated in the engraving, and there is a retaining valve near to the air vessel which prevents leakage when the pump is stopped.

Condenser and air pump.—The surface condenser is fixed and connected as shown. The condenser tubes are of the diameter requisite to offer a minimum of frictional resistance to the water passing them to the main pump. The air pump (in this case) is driven by an eccentric on the crank shaft.

The boiler is of the Cornish type (Fig. 1522, Section I.) and is complete with all mountings, feed apparatus, cast-iron flanged pipes coated with non-conductor, steam stop-valve, &c.

Duplicate engine and boiler.—Space was left for these but the need for them has not arisen.

The price of the installation above described is about £1500

PUMPING ENGINE TO SUPPLY 10,000 GALLONS PER HOUR and deliver to a height of 170 feet. The supply is obtained from a well about 47 feet deep, but the water is usually within a few feet of the surface and is lifted by a ram and bucket pump to a tank from which it flows into a horizontal double-acting pump of the type above described.

The arrangement of machinery is indicated with sufficient accuracy in the diagrams Figs. 2514 and 2515, the proportions being modified to suit the conditions to be fulfilled.

The price of this installation, including two Cornish boilers with fittings and connections, delivered on trucks, is about £900

Duplicate pumping plant.—The demand for water supply having largely increased since the machinery now referred to was supplied, a second set and a third boiler have been erected in the spaces provided for that purpose.

POWER AND HAND-WORKED WELL PUMPS.

It is difficult adequately to illustrate the wide range of appliances comprised under this heading, but the following engravings and descriptions indicate the types in general use, and the kind of information required for designing arrangements of machinery suitable for the exceptional conditions so often met with in the construction of plant for water supply.

Motive Power.—The quantity of water to be raised in a given time, and the total height of lift having been determined, the power necessary for that duty will be ascertained by reference to one or other of the tables. This information will serve as a guide in arranging for the motive power which will be employed to most advantage under existing local conditions; the approximate cost of different kinds of motors, well frames, etc. will be found in the following pages.

Pump rods, pipes, and other accessories.—The arrangements for suction and delivery, the positions of both, relatively with the source of supply and the distance to which they are carried, vary very widely; but by consulting the tables relating to the cost of component parts, all of which are clearly defined, the cost of a suitable installation of pumping machinery may be estimated with considerable accuracy.

Steel or wrought iron pipes.—Attention is directed to the advantages sometimes obtained by using these pipes in preference to cast iron. The cost of current sizes will be found under their respective headings.

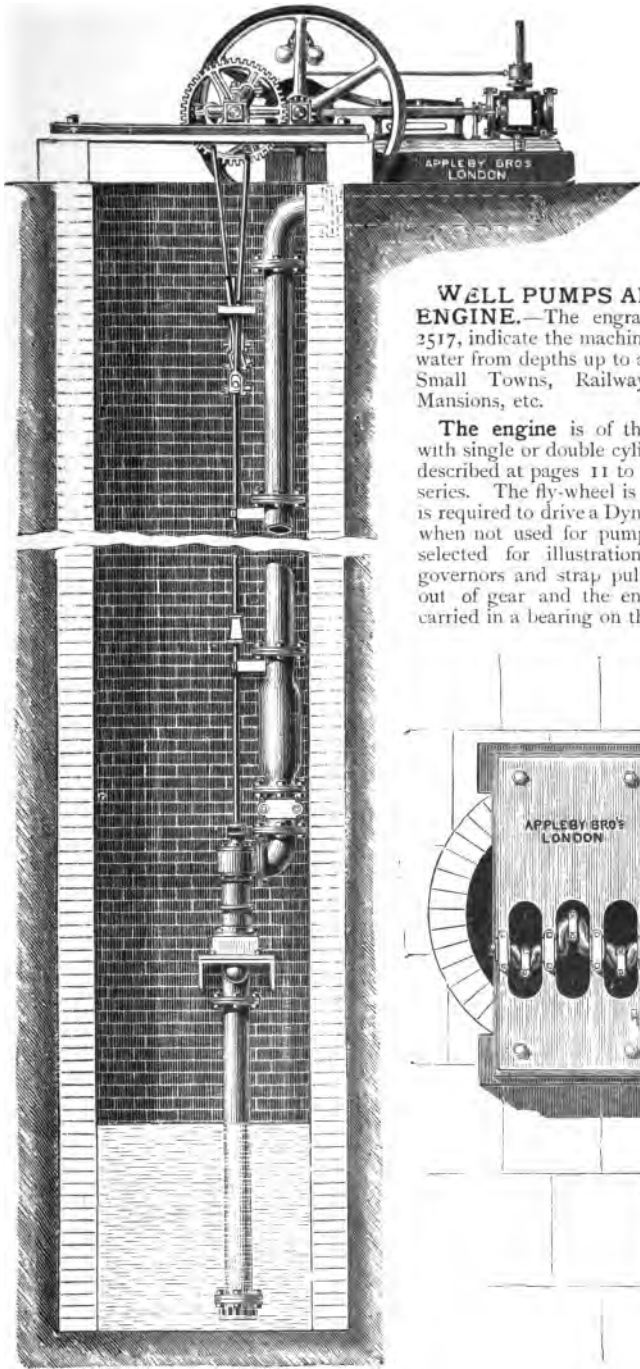


Fig 2517.

WELL PUMPS AND HORIZONTAL ENGINE.—The engravings, Figs. 2516 and 2517, indicate the machinery employed for raising water from depths up to about 150 feet to supply Small Towns, Railway Stations, Factories, Mansions, etc.

The engine is of the most approved type, with single or double cylinders, as illustrated and described at pages 11 to 20 of Section I. of this series. The fly-wheel is turned if the engine is required to drive a Dynamo or other machinery, when not used for pumping, as in the example selected for illustration, it is provided with governors and strap pulley. The pinion slides out of gear and the end of the crank shaft is carried in a bearing on the well frame plate.

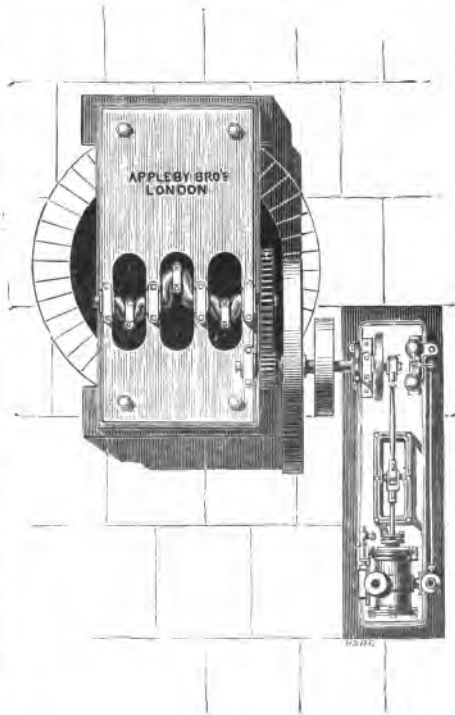


Fig. 2516.

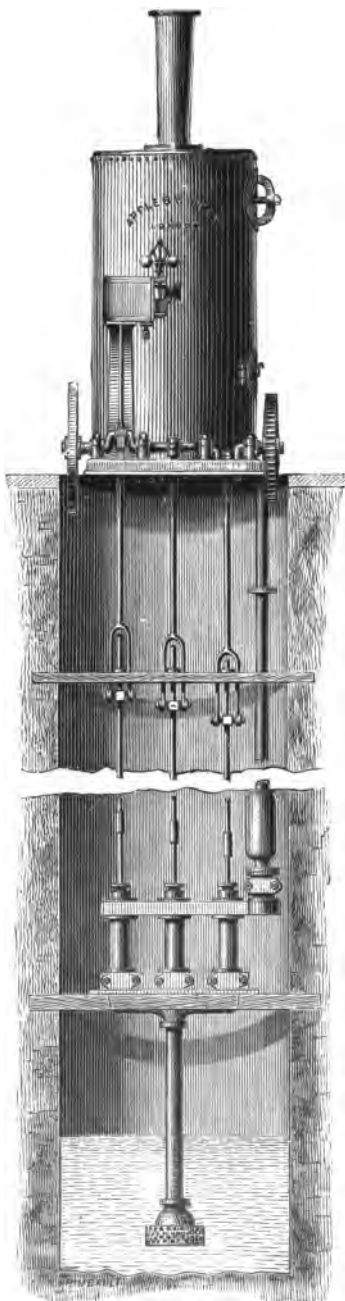


Fig. 2518.

The pump crank plate is of cast iron, as illustrated, for small wells, or it is carried on wrought iron girders for wells of large diameter.

The three throw crank is of wrought iron or mild steel, and is supported by pedestals with gun-metal bearings, caps, lock nuts, lubricators, etc.

The connecting rods are of wrought iron, forked to clear the pump rod guides, and fitted with gun-metal bearings.

The treble barrel pumps are as illustrated by Fig. 2526, and are complete with suction pipe and strainer, air vessel and rising main of the length and arrangement required. The pump rods have sliding well rod joints and gun-metal guides. The well stays are in timber and were provided by the well-sinker, but they are made in iron and sent with the pumps if desired.

The cost of machinery cannot be defined without details relating to the quantity to be raised in a given time, the depth of the well, and the maximum height of delivery above surface. Should sufficient steam power be available the pressure only need be stated.

Approximate estimates will easily be made by reference to the prices of machinery and materials which will be found further on (see index) and in Section I.

The tables and memoranda elsewhere in this section relating to water supply, capacity of pumps, etc. will be useful when approximate estimates are being prepared.

WELL PUMPS, WITH VERTICAL ENGINE AND BOILER.—Fig. 2518 represents a set of pumps similar to those shown in Fig. 2516, but driven by a vertical engine of the type Fig. 1511 (Section I.) and is complete with boiler, fittings and connections. Similar installations with double and single pumps (Figs. 2528 and 2529) or double acting pumps (Fig. 2535) are referred to elsewhere.

For domestic water supply (and for many other purposes) the pumps are made of gun-metal and the bottom rod is of copper.

The prices of the pumps cannot be determined without information of the kind mentioned at page 4, but the approximate cost can be estimated by reference to the prices of suitable pumps and accessories (see index).

The pumping plant, Fig. 2518, raises 9500 gallons per hour to a height of 100 feet, for the service of a small town; it consists of a vertical engine and boiler, with fittings and connections, well frame and gear, treble barrel gun-metal pumps, pump rods, suction and delivery pipes with flanged joints, bolts, etc., strainer on the suction pipe, air vessel with retaining valve to rising main, and all metallic accessories ready for fixing.

The price of this pumping plant is about ... £275

A pumping plant as above, but to deliver 2000 gallons of water per hour to a height of 280 feet, or a proportionately larger quantity at a lower elevation, is about ... £265

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

TREBLE AND DOUBLE BARREL PUMPS, WITH HORSE or CATTLE GEARS.—The pump

is as shown on a larger scale in Fig. 2526, and the gears for horse, pony or cattle, with one, two or four poles (as may be suitable for the work) are as indicated in the engraving and as illustrated and described at pages 97 and 98 of Section I.

An intermediate gear is required for quick working pumps, and should always be provided for gears worked by bullocks to accelerate the speed.

The three throw crank is of wrought iron turned in all journals, and is carried in pedestals with gun-metal bearings, caps, and lock nuts. The well plate spans the well, or is carried on girders as circumstances require.

The connecting rods are of wrought iron, with adjustable gun-metal heads and bearings in the forked ends which connect them with the pump rods.

The pump rods are of wrought iron, with brass socketed well rod joints; the upper end is turned above the trunion and works in a gun-metal guide.

The pump rod guides are attached to timber or iron stages (usually the former) which are fixed at intervals of 10 to 12 feet, as shown.

The duty of the pumps is given for a normal speed of 30 strokes per minute; the quantity delivered is (of course) in proportion with the higher or lower speed of working.

The power of horses, bullocks, etc. is referred to at page 4, but—approximately—it may be assumed that the power of one bullock is equivalent to about 40 per cent. of that a strong horse can exert; so that if a horse raises a given quantity of water to a height of 100 feet, a bullock will raise four tenths of the quantity to the same height, or an equal quantity to a height of 40 feet.

The following prices include the horse gears, well plate, crank and gear at the surface; also the pumps and pipes, pump rods and connecting rods. An air vessel equalises the flow of water, but is not essential for low lifts and as it may not be required, the cost is given separately (see index.)

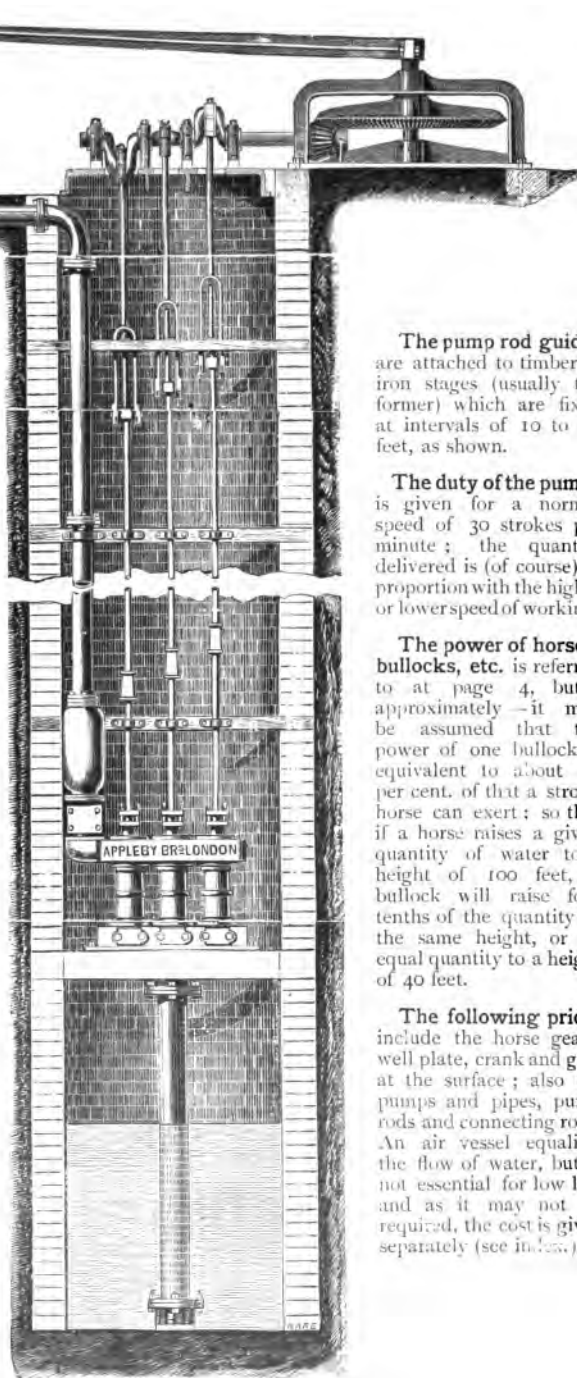


Fig. 2519.

PRICES OF TREBLE BARREL PUMPS WITH HORSE GEARS, Fig. 2519.

Diameter of pumps ... ..inches	2½	3	3½	4
Capacity, for 1 horse, at 30 strokes per minute gallons per hour	860	1240	1640	2150
Price of machinery for 30 feet depth, iron barrels ...	£55	£60	£65	£70
" " gun-metal " ...	£58	£63	£69	£75
Extra per foot beyond 30 feet... ..	4/-	4/6	5/-	5/6
" for intermediate motion to horse gear about	£3	£3 10 0	£3 10 0	£4

PRICES OF DOUBLE BARREL PUMPS WITH HORSE GEARS, as Fig. 2519.

Diameter of pumps ... ..inches	2½	3	3½	4
Capacity at 30 strokes per minute gallons per hour	550	800	1100	1400
Price of machinery for 30 feet depth, iron barrel	£33	£35	£37	£40
" " gun-metal " ...	£35	£37	£40	£43
Extra per foot beyond 30 feet... ..	2/9	3/-	3/3	3/6

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

INSTALLATIONS OF PUMPING MACHINERY.—As mentioned elsewhere, the cost of pumping plant cannot be accurately estimated without details of the quantity of water or other liquid to be raised to a given height in a given time, the kind of motive power desirable, &c. The following information will, however, be of some assistance in calculating the approximate cost of machinery for most purposes, and so save time in correspondence.

Attention is directed to the necessity for ample provision for losses in efficiency due to friction, wear and tear, and (possible) negligence in maintenance. In other words—within reasonable limits—the larger the proportions, the smaller will be the cost of maintenance.

WELL FRAMES, WITH STEAM ENGINE AND BOILER.—The engine is either horizontal as Figs. 2516 and 2517, or vertical as Fig. 2518, but more accurately represented by Figs. 1510 and 1511 (Section I.). The proportions are ample and the materials and workmanship are the best of their respective kinds.

The boiler is of the well-known vertical type, with cross tubes in the fire box, and complete with chimney, all furnace, steam, and feed water fittings, and connections to the engine for a distance not exceeding 12 feet.

The well crank frame is of cast or wrought iron, as may be convenient; the three-throw crank is of wrought iron, turned for all journals and carried in pedestals with gun-metal bearings, covers and lock nuts. The three cranks are fitted with wrought iron forked connecting rods with gun-metal bearings, guide rods and gun-metal guides.

PRICES OF ENGINE, BOILER, AND WELL FRAME, Figs. 2516 and 2518.

Nominal horse power of engine	2	3	4	6
Price of machinery as described	£75	£100	£135	£160

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

WELL FRAMES WITH GAS OR OIL ENGINES.—Engines of these types (with proper lubrication) work for hours without any attention, and, as skilled labour is quite unnecessary, the cost of pumping is rarely more than half that of steam power used on a small scale; if the work is intermittent, even this large margin is frequently exceeded.

The engine and pump gear may be fixed on one bed plate as in Fig. 2518, a friction clutch being provided for starting the pumps after the engine has made a few strokes, but driving the pump by belt, with fast and loose pulleys on the well crank shaft is usually more convenient and less costly. The engine is of the usual type as illustrated and described at pages 78 and 79 of Section I.

The following approximate prices include the gas or oil engine with turned fly wheel or pulley for belt, three-throw crank shaft with fast and loose pulleys, reducing gear, forked connecting rods, guide rods, gun-metal guides, etc.

For prices of pipes, well rods and accessories see pages 30 to 39, etc.

PRICE OF GAS OR OIL ENGINE AND WELL FRAME.

Effective horse power of engine	4	5	6	8
Price of machinery as described	£100	£125	£150	£175

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

WELL FRAME WITH ELECTRIC MOTOR.—The motor may be attached to the well frame, but driving by belt has the preference under ordinary conditions as regards space, etc., and the following prices are based on the cost of machinery, as last described, with pulleys for driving by belt.

PRICE OF ELECTRIC MOTOR AND WELL FRAME.

Effective horse power of motor	4	5	6	8
Price of pumping machinery	£100	£115	£140	£165

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

WELL FRAMES WITH HORSE OR CATTLE GEAR consist of the well frame, crank, connecting rods, etc., as above described, and the horse gear with lever and crosstree, as illustrated in Fig. 2519.

The price of machinery for well 40 feet deep is £15
 " " " 60 feet " £18

The price of intermediate motion is respectively £3 and £4

For prices of pumps, pipes, rods, and accessories, pages 30 to 39, etc.

WATER WHEELS AND PUMPS.—The cost of plant for raising water from a low level for farm, plantation, or house supply, by water power, may be greater than for some of the other methods referred to, but the cost of working is so low that it is often used to advantage.

Pumping plant of this kind should be built to suit the local conditions, such as the volume and head of drive water, the quantity and lift of water supply required, &c. but the following information may serve as a basis for approximate estimate.

The water wheels referred to below are of the type Fig. 1639 (Section I.); the pump is driven from a disc and crank pin on the end of the wheel gudgeon, with appliances for altering the stroke of the pump.

The approximate prices include the water wheel with bearings and lubricators, double-acting lift and force pump, with connecting rod to the pump, all ready for erection.

PRICES OF WATER WHEELS AND PUMPS.

Diameter of water wheel feet	4	5	6	7	8	9
Pumping capacity, gallons. per 24 hours ...	2500	2500	2500	2500	2500	2500
Height of lift feet	100	120	130	130	130	130
Price of pumping plant about	£30	£38	£44	£49	£54	£60

The cost of packing for shipment and deliver f.o.b. is about 5 per cent.

DEEP WELL PUMPS DRIVEN BY TURBINE OR WATER WHEEL.—A set of pumps with well frame, of one of the types illustrated, may be driven by belt, rope, or gear from a turbine fixed as indicated in Fig. 1629 (Section I.), by quadrant arm or in other convenient manner.

Information relative to turbines and water wheels will be found at pages 84 to 96 of Section I.

WINDMILLS AND PUMPS.—Fig. 2520 illustrates a windmill with appliances for stopping and starting and for automatically regulating the openings between the vanes and so avoid damage during a sudden storm.

These mills drive any kind of machinery and are specially adapted for working pumps which supply water for farm, domestic or other purposes.

Dimensions of Mills.—The sails vary in diameter from 7 to 50 feet and are arranged for fixing on timber, iron, or masonry towers ranging from 16 to 50 feet in height. It will scarcely be necessary to point out that the tower must be high enough to give the wind unobstructed access to the sails. Fig. 1640 in Section 1 represents a type of mill and tower suitable for the larger powers.

Power of windmills.—When the velocity of the wind is 18 to 20 miles per hour, usually called "a brisk wind," the power is four times greater than that developed by the same mill with a 10 mile wind or "pleasant breeze" which often prevails for many hours on most days. For this reason the pumping capacities mentioned below have been based on a 10 mile wind.

If this is less than the average in the locality where the mill is to work, the alternatives are to provide storage for water and run longer hours, or have a mill with larger sail which will supply the minimum quantity required in a given time.

The pumping capacity is in direct proportion with the height of delivery above water level; therefore, if this height is 100 feet the quantity will be half of that delivered at a height of 50 feet, and so on.

Types of pumps.—An ordinary single barrel pump, or a chain pump, answers every purpose for raising moderate quantities of water from a depth not exceeding about 25 feet and



Fig. 2520.

delivering at the surface. But an air vessel is required for a single barrel reciprocating pump if the delivery is much above ground level.

For larger quantities, however, treble barrel pumps should be used; these may be fixed horizontally for surface suction, or vertically in the well, with head gear as indicated in Fig. 2515, etc., as may be convenient.

The prices include pumps of the capacities specified, self regulating sails, the requisite shafting, ironwork for fixing to towers, and the foundation bolts and plates. The cost of machinery and pumps and of the tower is given on the following page.

PRICES OF WINDMILL MACHINERY AND PUMPS.

Diameter of sail feet	10	12	16	20
Capacity of pumps, gallons per hour, 100 feet lift ...	115	230	475	950
Price of machinery for tower ... 16 feet high	£20	£29	...	...
" " " " " 20 "	£21	£30	£56	...
" " " " " 25 "	£24	£32	£58	£98
" " " " " 30 "	£25	£34	£62	£100
" " " " " 40 "	£27	£36	£65	£105
" " " " " 50 "	£30	£38	£73	£112

TOWERS FOR WINDMILLS in iron or timber of suitable construction and dimensions, ready to receive the machinery and marked for re-erection, can be supplied at the following (approximate) prices. A tower in timber can be quite well built locally and of native wood.

A masonry or concrete tower is perhaps more satisfactory for mills of large power.

PRICES OF WINDMILL TOWERS.

Diameter of sail feet	10	12	16	20
Price of tower in iron 16 feet high	£17	£18	...	...
" timber 16 "	£5	£6	...	...
" iron 20 "	£18	£20	£29	...
" timber 20 "	£6	£7	£12	...
" iron 25 "	£30	£32	£38	£46
" timber 25 "	£11	£12	£17	£20
" iron 30 "	£32	£34	£42	£50
" timber 30 "	£13	£14	£19	£25
" iron 40 "	£38	£40	£50	£58
" timber 40 "	£19	£20	£25	£33
" iron 50 "	£48	£50	£58	£68
" timber 50 "	£30	£31	£36	£45

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

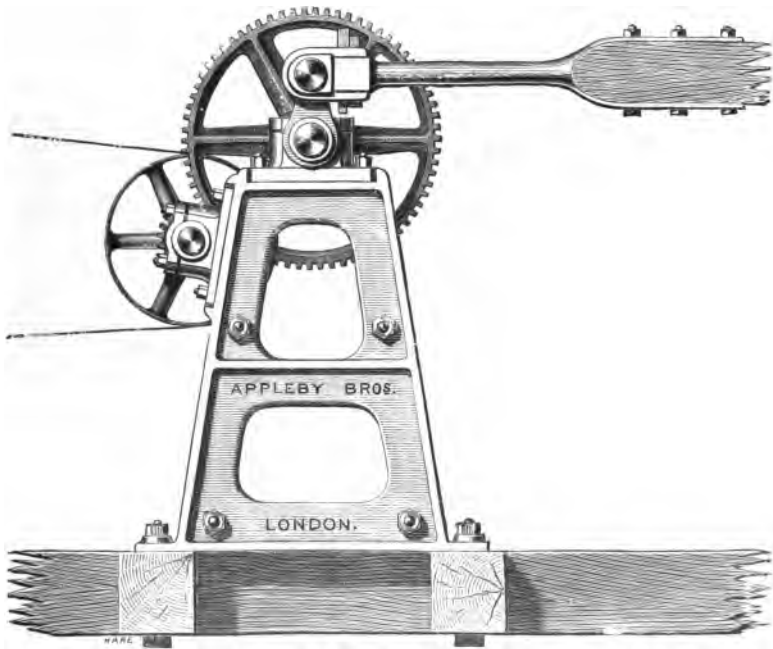


Fig. 2521.

INTERMEDIATE DRIVING GEAR FOR PUMPS, similar to Fig. 2521, is frequently required for reducing the speed between the engine (or other motor) and pump, such as those illustrated by Fig. 2611 and other engravings. The light pattern is suitable for pumps of medium diameters and for comparatively low lifts, and the other for the higher duty and constant work required from pumps of the type Fig. 2609.

The side frames are cast iron, provided with pedestals and gun-metal adjustable bearings, loose caps and lock nuts, and firmly secured by stay bolts. The gear shown in the engraving consists of the driving pulley for belt or rope, crank arm and pin, and wrought iron connections for attachment to the rod to pump.

For driving direct from the engine, the pulley, pinions, shaft and bearings for it are omitted, and the spur wheel is driven by a pinion keyed on the engine shaft.

PRICES OF INTERMEDIATE DRIVING GEAR, Fig. 2521.

Type of Gear	...	...	...	...	...	Light	Heavy
Price of gear as illustrated, Fig. 2521	...	...	...	...	...	£24	£38
„ without intermediate shaft, etc.	...	...	...	...	...	£18	£30

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

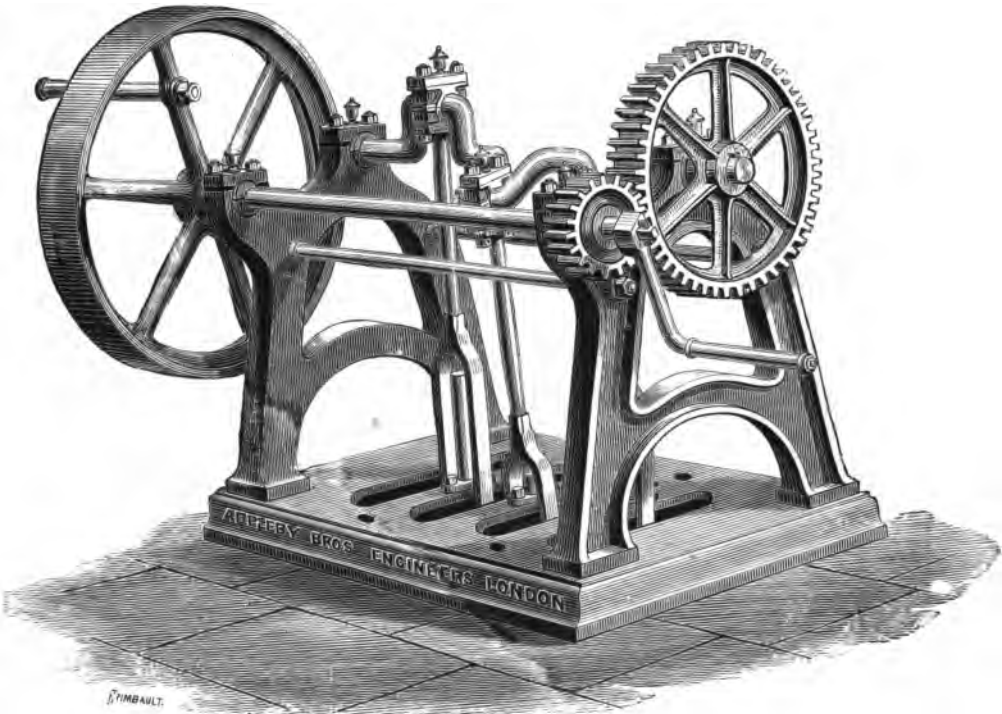


Fig. 2522.

TREBLE BARREL WELL PUMPS WITH HAND POWER GEAR.—

The well frame for treble pumps illustrated by Fig. 2522 is suitable for wells of any depth which can be worked with advantage by manual power, or a pulley can be substituted for the crank handle for driving by belt, rope, or gear.

The cost of the pulley is about £3 to £5, the pump being always available for temporary use by hand power.

The pump and fittings are similar to those represented in Fig. 2514, and comprise all accessories—excepting the air vessel and well stages—for a depth of 30 feet from surface to strainer on the suction pipe.

PRICES OF TREBLE BARREL PUMPS WITH GEARED WELL FRAME.

Diameter of pumps	...	...	...	inches	2½	3	3½	4
Capacity at 30 strokes per minute, gallons per hour	...	...	...	...	860	1240	1640	2150
Price of machinery for 30 feet deep, iron barrels	...	...	...	...	£55	£60	£65	£70
Price of machinery for 30 feet deep, gun-metal barrels	...	...	...	...	£57	£63	£69	£75
Extra per foot beyond 30 feet	...	...	...	...	4/-	4/6	5/-	5/6

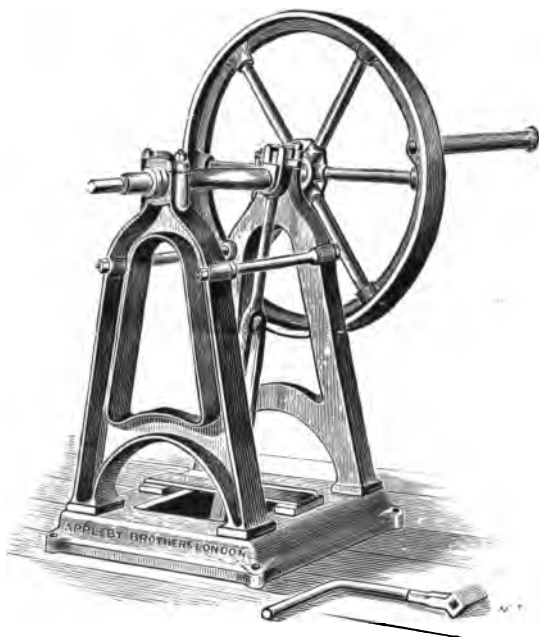


Fig. 2523.

DOUBLE AND SINGLE BARREL PUMPS WITH WELL FRAMES are made as illustrated by Fig. 2523, or with gear to reduce the power exerted and the speed of lift, and both can be fitted with strap pulley for driving by power.

The prices include the well frame with crank shaft, fly wheel and handles, well rods, gun-metal pumps, iron air vessel, foot valve and strainer.

PRICES OF DOUBLE BARREL WELL FRAME AND PUMPS, Fig. 2523.

Diameter of pumps inches	2½	3	3½	4
„ suction pipes „	1½	2	2	2½
„ delivery „	1½	1½	2	2
Capacity, gallons per hour at 30 strokes per minute	550	800	1100	1400
Height lifted by one man feet	25	18	13	10
Price of pumps for 30 feet deep	£23	£25	£28	£32
„ „ 60 „	£25	£27	£30	£34
Extra for geared frame	50/-	54/-	60/-	68/-
„ belt pulleys	12/-	14/-	16/-	18/-

PRICES OF SINGLE BARREL WELL FRAME AND PUMPS, Fig. 2523.

Diameter of pump inches	2½	3	3½	4
Capacity, gallons per hour	275	400	550	700
Height lifted by one man feet	50	35	25	20
Price of pump for 30 feet deep	£16	£18	£20	£22
„ „ 60 „	£17	£19	£21	£23

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

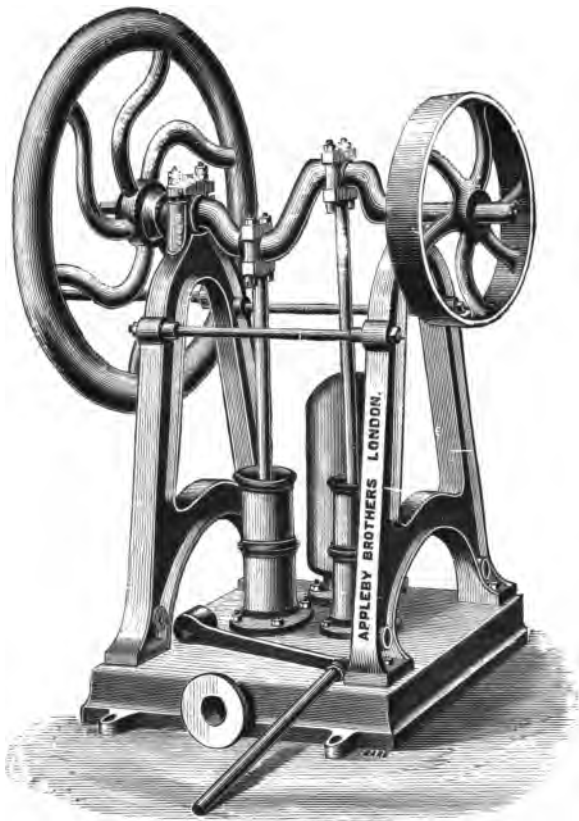


Fig. 2524.

DOUBLE BARREL LIFT AND FORCE PUMPS of the type, Fig. 2524, are adapted for stations, ships, and other purposes where the suction does not exceed 27 feet, the delivery may be carried to any usual distance or height; they were originally made for use at the diamond mines.

The pump barrels are of gun-metal with open tops, and gun-metal plungers; the suction and delivery connections are conveniently arranged, and the air-vessel is complete with all accessories.

The crank shaft is of mild steel, and is carried in gun-metal bearings with loose caps and lock nuts. The connecting rods are of wrought iron with gun-metal heads.

The driving power may be by belt or rope, and a large number of pumps, made for the mines, are fitted with V grooved pulley for working by rope, the power being transmitted from a distance.

Prices and capacities.—The prices are for hand worked pumps and the approximate capacities are for a speed of about 30 strokes per minute.

PRICES OF DOUBLE BARREL FORCE PUMPS, Fig. 2524.

Diameter of barrel	... .. inches	2½	3	3½
Capacity, gallons per hour	... .. about	480	625	870
Price of pump	... ..	£22	£24	£28
„ extra for V grooved fly wheel	... ..	20/-	20/-	20/-

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

PRICES OF DOUBLE ACTING FORCE PUMPS, FIG. 2525.

Diameter of barrel	... .. inches	4½	5	5½
„ plunger	... ..	3	3½	4
Capacity, gallons per hour, 30 strokes per minute, about	... ..	550	750	950
Price of pump	... ..	£20	£22	£28

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

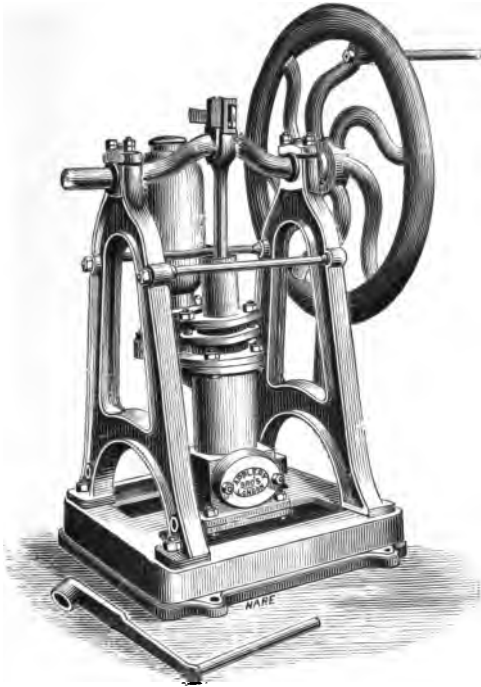


Fig. 2525.

DOUBLE ACTING FORCE PUMP.—Fig. 2525 is engraved from a photograph of pumps, built for raising water from a depth of about 25 feet, and forcing it into tanks at a considerable elevation, for the water supply of railway stations and adjoining houses.

The pump barrel is of cast iron (or gun-metal as may be necessary) and is fitted with brass plunger and valves, and door for access to them. The connecting rod is of wrought iron fitted, at the upper end, with gun-metal bearings. The gland is packed externally, and the cast iron air vessel, with retaining valve, is carried on a bracket attached to the pump barrel.

The side frames have planed seats and wrought iron stays, and are fitted with gun-metal bearings for the crank shaft, loose caps and lock nuts.

The crank shaft is of mild steel and of the length necessary for taking a pulley for driving by belt. The other end is provided with a heavy fly-wheel and handle, or with a V-grooved wheel for driving by rope.

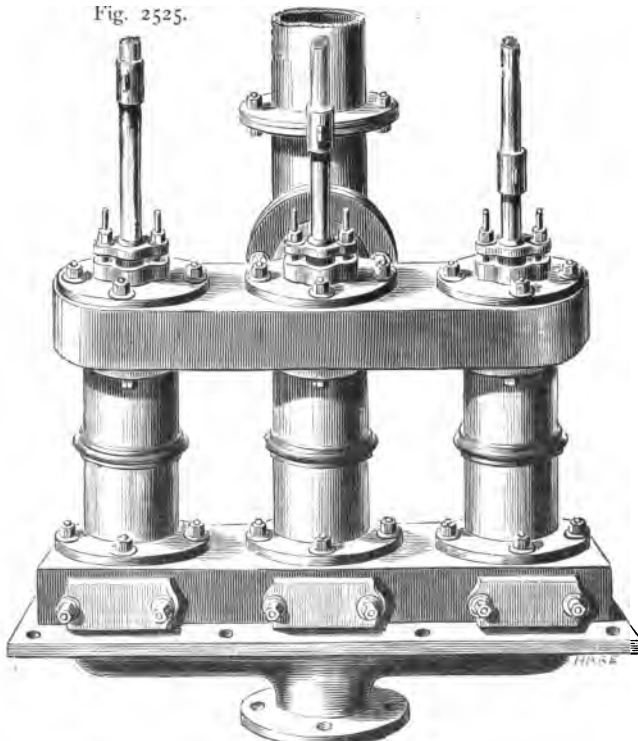


Fig. 2526.

TREBLE BARREL FULL WAY LIFT AND FORCE PUMPS.—

Fig. 2526 represents pumps with cast iron, gun-metal, or brass barrels; the bucket rods are of mild steel, copper, or one of the above-named metals.

The pump barrels are strengthened externally by rings, and the flanges are bolted respectively to the valve chamber and breeches piece; the former has a flanged connection for the suction pipe, and the latter a similar connection for the rising main. The base has a wide flange on each side with holes for bolts to fix the pumps to the well stages.

Pumps of large diameter, or for exceptionally high lifts, are provided with bolts between the base and the head which relieve the connections of undue strains.

The bucket rods are turned, and work in gun-metal glands accessible for packing, and doors to the valve chambers afford facilities for examining the foot valves.

The standard length of barrel given below is modified if necessary.

The approximate duty is based on the maximum speed at which the respective sizes of pumps should work, but ample allowance should be made for wear and tear, and the low speed desirable for pumps in constant use.

Pumps for low lifts, of lighter construction are illustrated by Figs. 2527 to 2529.

The prices of pipes, foot valves, strainers, and other fittings will be found under the heading "Pump Fittings."

PRICES OF TREBLE BARREL PUMPS, FIG. 2526.

Diameter of barrel	inches	2½	3	3½	4	5	6
Length of stroke...	"	9	9	9	9	12	12
Capacity, gallons per hour	...	1550	2200	3000	4000	6500	8500
Diameter of pipes	inches	2½	3	3½	4	5	6
Prices of iron pumps	...	£15	£17	£20	£25	£34	£47
" gun-metal pumps	...	£17	£20	£23	£30	£48	£69
" iron air vessels	...	£1.5	£1.10	£1.18	£2.5	£2.15	£3.5
" copper	...	£2.5	£2.10	£2.15	£3.10	£4	£4.10

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

DOUBLE AND SINGLE BARREL LIFT AND FORCE PUMPS

are fitted and finished precisely as last described, and have doors for access to the valve chamber. The prices of accessories are as above.

PRICES OF DOUBLE BARREL PUMPS.

Diameter of barrel	inches	2½	3	3½	4	5	6
Length of stroke	"	9	9	9	9	12	12
Capacity, gallons per hour	...	1000	1450	2000	2600	4300	5600
Price of pump, iron	...	£10	£11.10	£13	£15	£21	£30
" gun-metal	...	£11.10	£13	£15	£18	£30	£41

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

PRICES OF SINGLE BARREL PUMPS.

Diameter of barrel	inches	2½	3	3½	4	5	6
Capacity, gallons per hour	...	500	725	1000	1300	1430	1860
Price of pump-iron barrel	...	£4	£5.10	£6.10	£8	£30	£18
" gun-metal barrel	...	£5	£6.10	£7.10	£9	£15	£21

TREBLE BARREL PUMPS WITH OUTSIDE PACKED GLANDS

are similar to those illustrated by Fig. 2526 and are much used for pumping sewage, tar and other liquids highly charged with insoluble matter. For this purpose the valves are metallic with doors for access to them; the rams are of gun-metal of the diameter mentioned with outside gland packings.

PRICES OF TREBLE RAM PUMPS WITH OUTSIDE GLANDS.

Diameter of rams	...	...	... inches	2½	3	3½	4	5	6
Price of pump	...	...	...	£25	£28	£33	£38	£42	£47

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

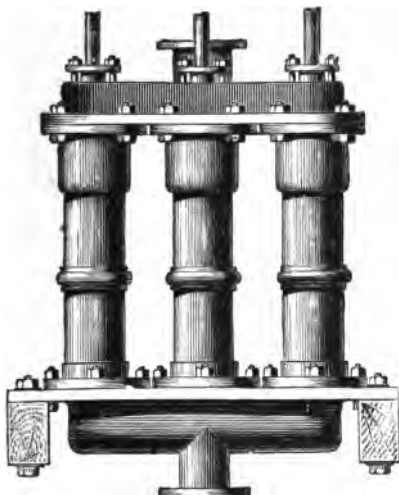


Fig. 2527.

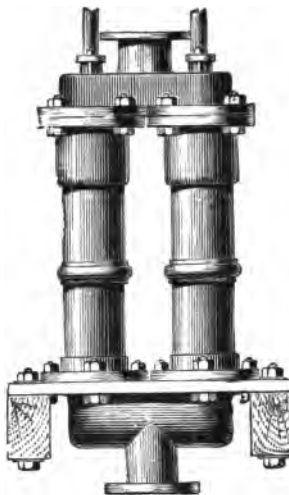


Fig. 2528.



Fig. 2529.

TREBLE, DOUBLE AND SINGLE PUMPS illustrated by Figs 2527 to 2529 are similar to those described at page 39, excepting that they are of the lighter section which suffices for surface or low lift pumping, and have not the valve chamber with doors indicated in Fig. 2526. The barrels can however be removed from the top chamber without disturbing the rising main, and each barrel has a brass bucket and valve and a retaining valve.

PRICES OF BRASS BARREL PUMPS, Fig. 2527 to 2529.

Diameter of barrel	...	...	... inches	2½	3	3½	4
Price of pump, treble barrel, Fig. 2527	...	...	...	£15	£17	£20	£22
" " double " Fig. 2528	...	...	...	£9	£11	£13	£15
" " single " Fig. 2529	...	...	...	£3 15	£4 15	£5 10	£7
Diameter of pipes	...	...	... inches	1½	2	2	2½

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

TREBLE BARREL RAM PUMPS.

TREBLE BARREL RAM PUMPS, illustrated by Figs. 2530 to 2533, possess the well-known advantage of maintaining a uniform flow, without concussion in the delivery pipe, and are constructed of the proportions required to raise any quantity or kind of liquid, to any height desired.

They are arranged horizontally or diagonally to be driven by electric motor, by engine or turbine direct (see Figs. 2530 and 2510), or by strap, rope, or spur gear from any motive power, and all of them are made to fix to foundations or mounted on an under carriage, with wheels for transport to where their services are required.

Being specially designed to fulfil special conditions, varying in every detail, it is evident that the prices of these pumps cannot be tabulated.

The **barrel and rams** are usually of cast iron with gun-metal glands accessible for packing externally. Each barrel is fixed on a girder bed-plate, and is provided with a separate valve chamber and air-vessel and door for access to the gun-metal suction and delivery valves. The three valve chambers are connected by a pipe, with a single delivery branch and provision for the suction pipe to be attached at either end. The pumps are tested to double their working pressure.

The **three throw crank shaft** is of mild steel or best wrought iron, and is carried in pedestals with heavy gun-metal adjustable bearings, caps and lock-nuts. The connecting rods are of forged scrap-iron, with gun-metal heads, and finished in the same manner as high-class engine work. The pinions are of malleable iron or cast steel, or the gear is of steel throughout, as circumstances require.

The **suction pipe** must be perfectly tight and the intake should never be more than about 25 feet below the pump. Pumps which force to a great height in one lift should (by preference) be arranged for the water to flow into and completely fill the barrel.

The **delivery pipes** should be of ample diameter, and—if possible—free from depressions or sharp bends. If depressions cannot be avoided, a “snift valve” should be inserted above them to allow any accumulation of air to escape.

HORIZONTAL PORTABLE TREBLE BARREL PUMPS WITH ELECTRIC MOTOR.—For use in dip working, or under other conditions where facilities for removal are desirable; the pumps, Fig. 2531, are mounted on a timber or wrought iron undercarriage, with flanged (or plain) wheels as shown in Fig. 2530.

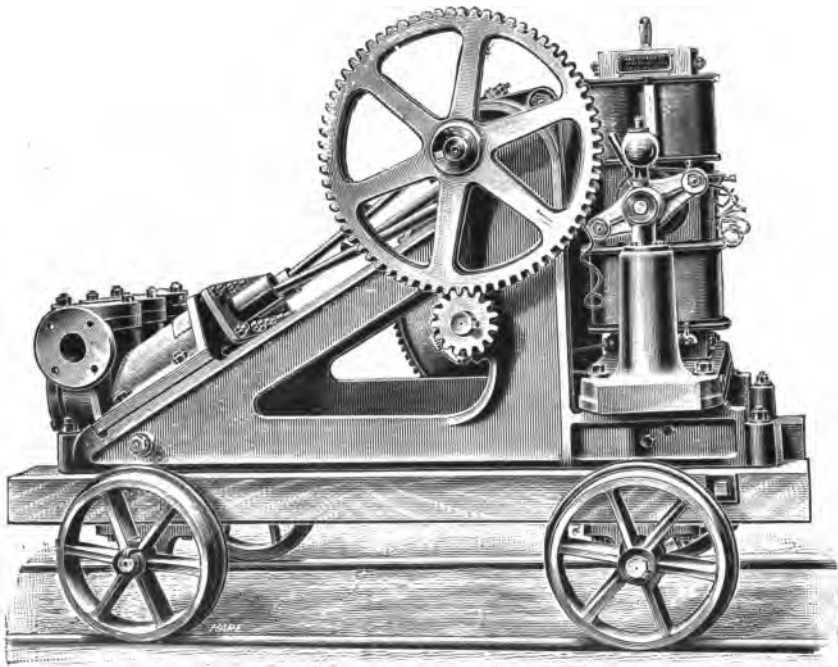


Fig. 2530.

DIAGONAL PORTABLE TREBLE BARREL PUMPS WITH ELECTRIC MOTOR.—Fig. 2530 represents a set of pumps carried on diagonal side frames, to occupy the shortest length in dip workings.

The pumps are constructed as already described, and may be either fixed or portable.

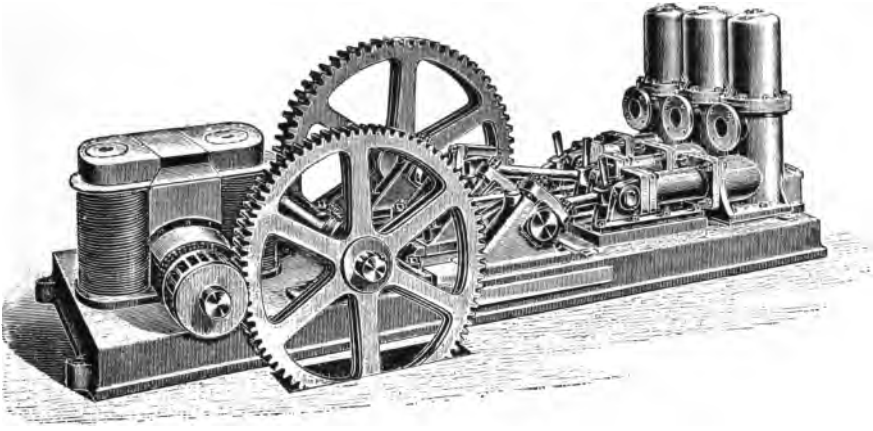


Fig. 2531.

HORIZONTAL FIXED TREBLE BARREL PUMPS WITH ELECTRIC MOTOR.—The pumps, Fig. 2531, are constructed as described above and are driven by an electric motor and reducing gear of ample power for the duty, all self-contained on one bed plate.

Where there is much moisture or dust, as in mines, &c. the Armature is usually enclosed hermetically.

If the current is supplied from an existing installation the voltage available should be stated.

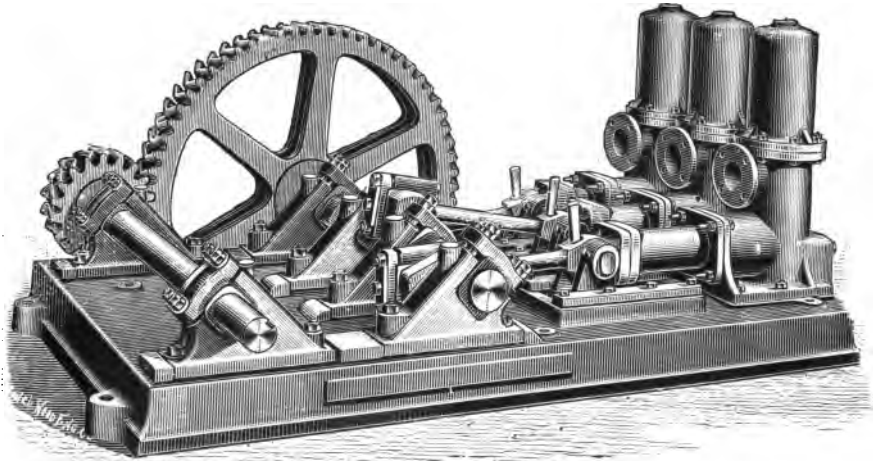


Fig. 2532.

HORIZONTAL FIXED TREBLE BARREL RAM PUMPS to be driven by engine direct, or by belt, rope, or spur gear.

The engraving Fig. 2532 illustrates the arrangement adopted for all sizes of these pumps and—unless some modification is necessary to adapt the pumps for raising exceptional kinds of liquids—the materials employed in their construction are described at page 43.

HORIZONTAL PORTABLE TREBLE BARREL RAM PUMPS are as above illustrated, but mounted on a travelling under carriage similar to Fig. 2530.

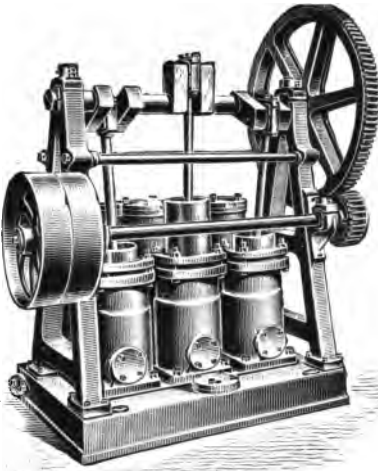


Fig. 2533.

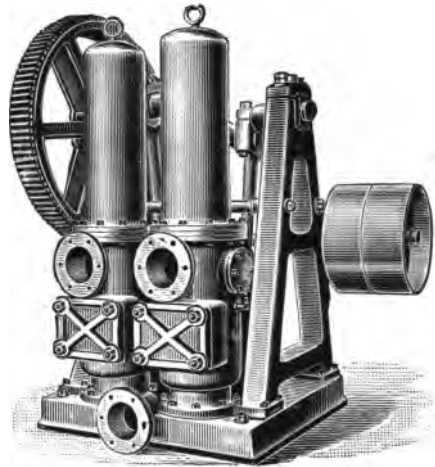


Fig. 2534.

VERTICAL TREBLE AND DOUBLE BARREL RAM PUMPS, Figs. 2533 and 2534, are driven by belt, ropes or gear, and are used for feeding boilers and for many other purposes.

The **pump barrels** are attached to the base plate and are fitted with hollow plungers. The suction and delivery valves are of gun-metal, and doors are provided for access to them.

The **crank shaft** is of forged steel, and all shafts are carried in adjustable gun-metal bearings. The materials and workmanship generally are similar to those used in the horizontal pumps, Fig. 2531.

The **gear and driving pulley** can usually be arranged to suit the speed of the pulley from which power is transmitted, provided that the dimensions and number of revolutions of the latter are stated.

The **approximate prices** are given for pumps of standard sizes, but this type is made for capacities up to 60,000 gallons per hour.

The **capacities of the pumps** are those obtained when working at the speeds specified, and are higher than desirable for constant work. This is mentioned in order that the proper allowance may be made, using a larger pump and working at a slower speed.

PRICES OF VERTICAL TREBLE BARREL RAM PUMPS, Fig. 2533.

Capacity, gallons per hour ...	780	1200	2000	3800	6000	9600	13200	17200
Diameter of pump ... inches	2	2½	3	4	5	6	7	8
Length of stroke ... "	3	4	5	6	6	8	9	10
Strokes per minute ...	130	100	90	80	80	70	60	50
Price of pump ...	£40	£47	£55	£80	£90	£125	£160	£220

PRICES OF VERTICAL DOUBLE BARREL RAM PUMPS, Fig. 2534.

Capacity, gallons per hour ...	1300	2550	4000	6400	8800	11500	13400	20000
Diameter of pump ... inches	3	4	5	6	7	8	9	10
Length of stroke ... "	5	6	6	8	9	10	10	12½
Strokes per minute ...	90	80	80	70	60	54	50	47
Price of pumps ...	£36	£47	£57	£75	£100	£125	£145	£200

The cost of packing for shipment and delivery f.o.b. is 5 per cent

DOUBLE ACTING PUMPS.

THE DOUBLE ACTING PUMPING ENGINE, Fig. 2535, raises 50,000 gallons of water per hour to a height of 160 feet for the service of an Imperial Palace, and is of larger dimensions than any of those referred to further on.

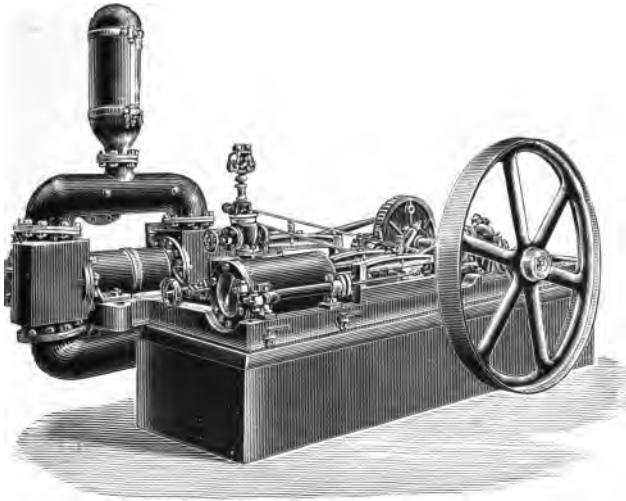


Fig. 2535.

The pump and valve box are of gun-metal; the barrel is 12 inches diameter and 24 inches stroke, the piston is of gun-metal and the piston rod is of steel sheathed with copper. The valves are of elastic phosphor bronze with gun-metal loose grid seats which are accessible for examination, and are easily renewed.

The beds for both pump and engine are of box section, with planed surfaces bolted together, and the pump is complete with air vessel and gauge on the connecting pipe between the delivery valve chambers.

The steam cylinder is 10 inches diameter and 20 inches stroke with metallic piston, steel piston and valve rods, gun-metal slide, high speed governors and the accessories usual in the best engine work.

The price of this engine with gun-metal pumps is about £480

If the pump is in iron the price is about £460

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

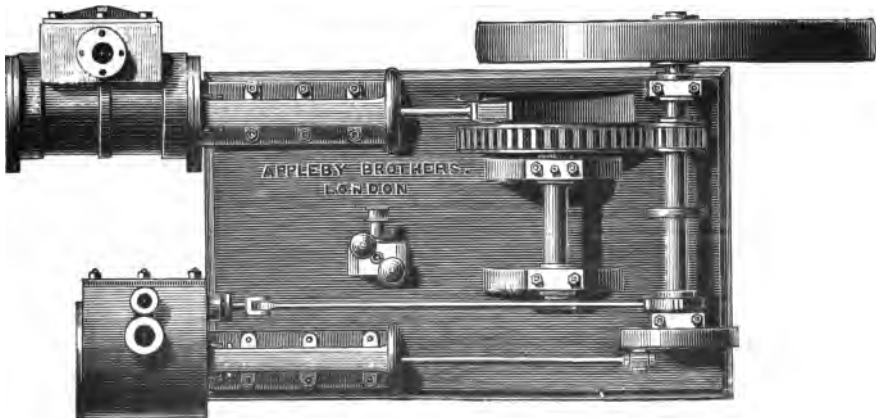


Fig. 2536.

DOUBLE ACTING PUMPING ENGINES.—Figs 2536 and 2537, illustrate two combinations for driving the pump Fig. 2543. Descriptions and prices of useful dimensions

will be found on the following pages, but the proportions are modified to any extent desired to suit the quantity to be pumped, the height or lift, the steam pressure available, etc.

The engine drives the pump through intermediate gear and is fitted with metallic piston, steel piston and valve rods and guides with ample wearingsurfaces; the crank and pump wheel shafts are of steel and are carried in pedestals with gun-metal bearings, caps and lock nuts.

The pinion on the crank shaft can be made to slide out of gear for the engine to be used to drive a dynamo or other machines when not pumping, and the engine Fig. 2536, is provided with governors and the fly wheel is turned for that purpose.

The pump is of close grained cast iron and is constructed as described at page 51. If the liquid to be raised is injured by contact with iron, the pump is made entirely of brass or gun-metal; the extra cost of this varies, but probably will not be more than about 15 per cent.

The air vessel (not shown in Fig. 2536) equalises the velocity of flow and avoids concussion in delivery pipes, if they are properly laid.

The duty in gallons raised is approximate, when the pump is in good working order, and is (of course) affected by the speed at which it is driven.

The pressure of steam is assumed to be not less than 60 lbs. per square inch. For prices of boilers, see page 24 to 36 of Section I.

For prices of pipes and connections in cast and wrought iron, foot valves, and other accessories, see "Pump Fittings."

PRICES OF HORIZONTAL DOUBLE ACTING PUMPING ENGINES, Fig. 2536.

Diameter of steam cylinder ... inches	4½	5	5½	6	6½	7½	8½
" pump " ... "	3	4	5	6	8	10	12
Stroke of pump ... "	10	12	12	12	14	14	15
Capacity gallons per hour ...	1100	2500	3800	5200	11500	17500	27000
Height of lift ... feet	250	230	200	200	100	85	70
Price of pumping engine ...	£55	£60	£78	£90	£115	£155	£185
Brass lining to pump extra ...	£3	£4	£5	£6	£7	£8	£11
Diameter of pipes ... inches	2½	3	3½	4½	6	8	9

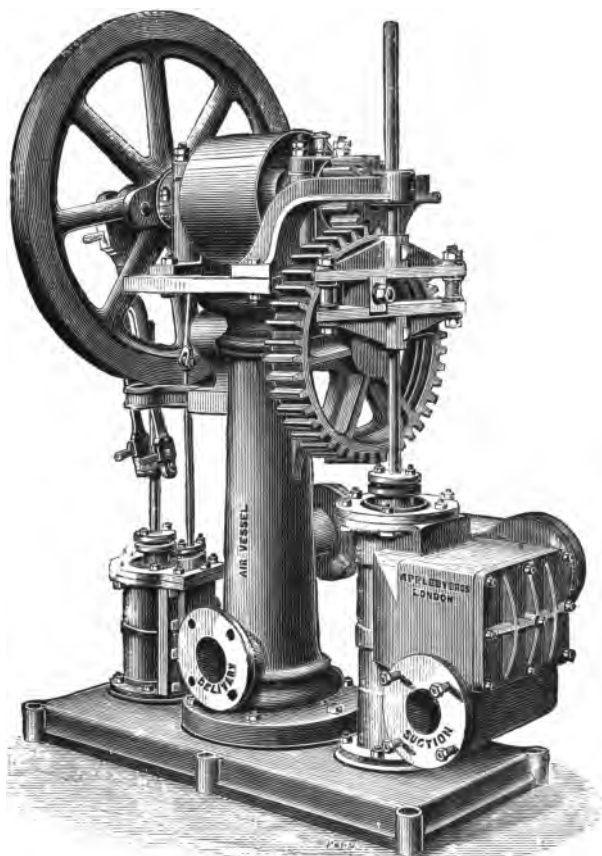


Fig. 2537.

VERTICAL DOUBLE ACTING PUMPING ENGINES.—The dimensions are practically the same as those specified for the horizontal type, Fig. 2536, so that every purpose is answered by giving the prices of the respective sizes.

PRICES OF VERTICAL DOUBLE ACTING ENGINES, Fig. 2537.

Diameter of pump inches	3	4	5	6	8	10	12
Price of pumping engine	£55	£65	£80	£95	£110	£160	£190

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

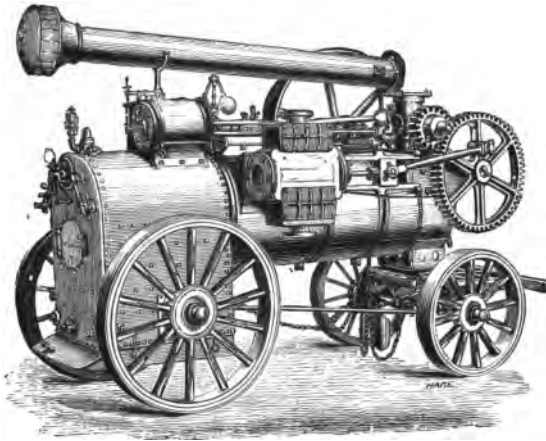


Fig. 2538.

PORTABLE ENGINE AND DOUBLE ACTING PUMP, Fig. 2538.—The engine is of the well-known type referred to in detail at pages 18 to 20 of Section I.

The double-acting pump, with guides, is carried on a strong saddle attached to the side of the boiler; the pinion on the crank shaft slides out of gear when the pump is not used and the engine is required to drive other machinery.

The pump barrel is of cast iron, with or without brass liner, the piston has double-cupped leather packings, and the rod is of mild steel working in an adjustable gland.

The valve chamber is fitted with gun-metal grid and india-rubber disc valves, which can be examined without disturbing either suction or delivery pipe.

The approximate duty mentioned below is that obtainable on the low lifts required for irrigation or drainage.

PRICES OF PORTABLE ENGINES AND DOUBLE-ACTING PUMPS, FIG. 2538.

Nominal horse power of engine	5	8
Diameter of pump inches	6	8
Capacity, gallons per hour	5500	10000
Price of engine and pump	£200	£260
„ „ „ brass lined	£205	£268
Approximate measurement... .. cubic feet	318	415

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

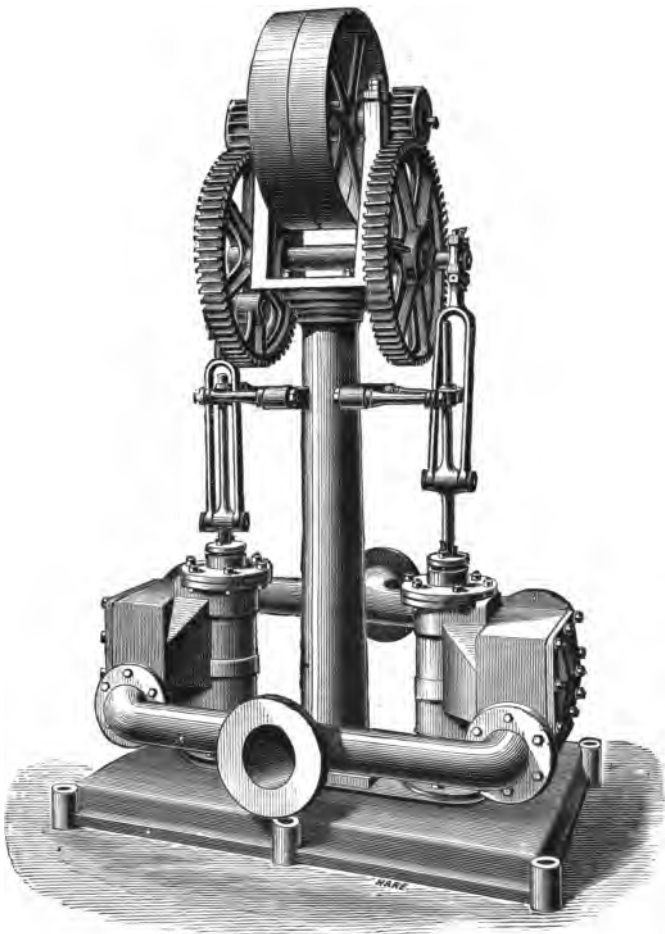


Fig. 2539.

BELT DRIVEN VERTICAL DOUBLE ACTING PUMPS.—Fig. 2539 represents a pair of pumps on one base plate, but the same construction is adopted for a single pump, the size of the bed plate being reduced and one set of gear omitted.

The pumps are as described in detail at page 51 and are mounted on a cast iron bed plate with central column which carries the fast and loose driving pulleys, and pump gear. If necessary, the column forms an air vessel in the manner shown in Fig. 2537.

PRICES FOR DOUBLE BARREL VERTICAL DOUBLE ACTING PUMPS, Fig. 2539.

Diameter of pump	...	...	inches	3	4	5	6	8
Capacity, gallons per hour...	...	...	...	2000	5000	6500	10400	23000
Price of pair of pumps	...	...	...	£45	£50	£60	£70	£85
" "	...	...	brass lined	£51	£58	£68	£82	£99

PRICES OF SINGLE BARREL VERTICAL DOUBLE ACTING PUMPS.

Diameter of pump inches	3	4	5	6	8
Capacity, gallons per hour... ..	1000	2500	3250	5200	11500
Price of single pump	£30	£35	£40	£45	£55
„ „ brass lined	£33	£39	£44	£51	£62

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

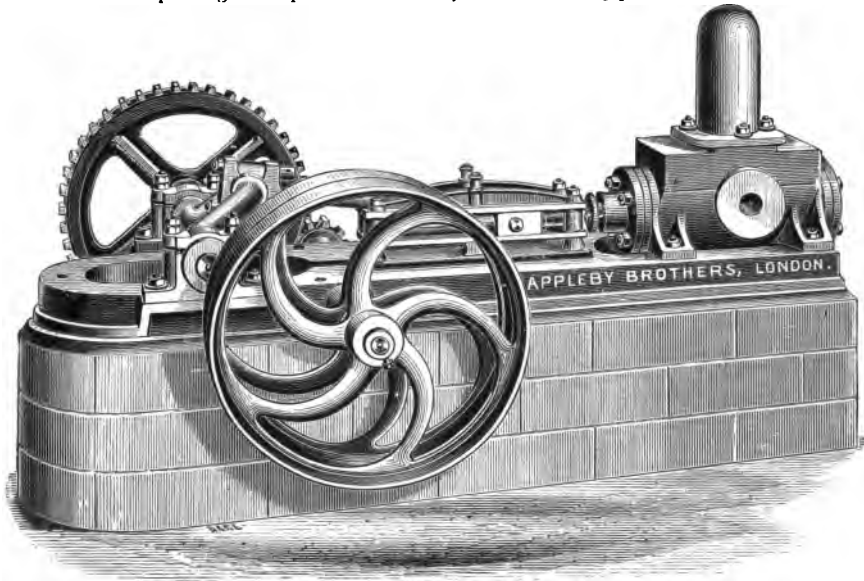


Fig. 2540.

BELT DRIVEN HORIZONTAL DOUBLE ACTING PUMPS, Fig. 2540—

The pump barrel, with air vessel, is fixed on a strong cast-iron bed-plate, the valves and connections are as described further on (see Fig. 2543).

The crank shaft is carried in pedestals with gun-metal bearings, loose caps and lock-nuts. The connecting rod is of wrought iron, and has adjustable gun-metal bearings; the piston and piston rod are as previously described, and the cross heads work in planed slides or in trunk guides, as shown in Fig. 2541, as may be convenient. The pinion shaft which carries the fast and loose driving pulleys is supported in bearings which form part of the bed-plate.

Approximate duty.—The quantities in the following table are calculated on a speed of about 40 strokes per minute, but this may be considerably increased if a larger delivery is temporarily required.

PRICES OF HORIZONTAL DOUBLE ACTING PUMPS, Fig. 2540.

Diameter of pump inches	3	4	5	6	8
Capacity, gallons per hour	1000	2500	3800	5200	11500
Price of pump	£35	£40	£45	£50	£65
„ „ brass lined	£38	£44	£50	£56	£72

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

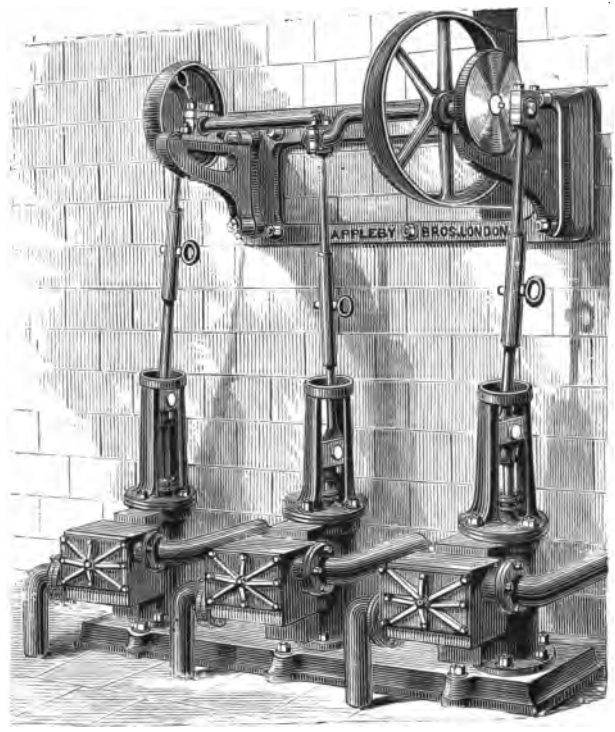


Fig. 2541.

SET OF THREE DOUBLE ACTING PUMPS.—Fig. 2541 illustrates one of many installations for Gas Works, where one pump, for raising water, is fitted with piston and valves like Fig. 2543, the other two pumps lifting tar and ammoniacal liquor, having cast iron ball valves. All the pumps are made of close grained cast iron, and the pipes are arranged as may be convenient.

The overhead driving gear is usually carried on a strong cast iron wall plate with brackets and gun-metal bearings for the crank shaft, or in other suitable manner ; or, if necessary, the pumps are arranged to work horizontally.

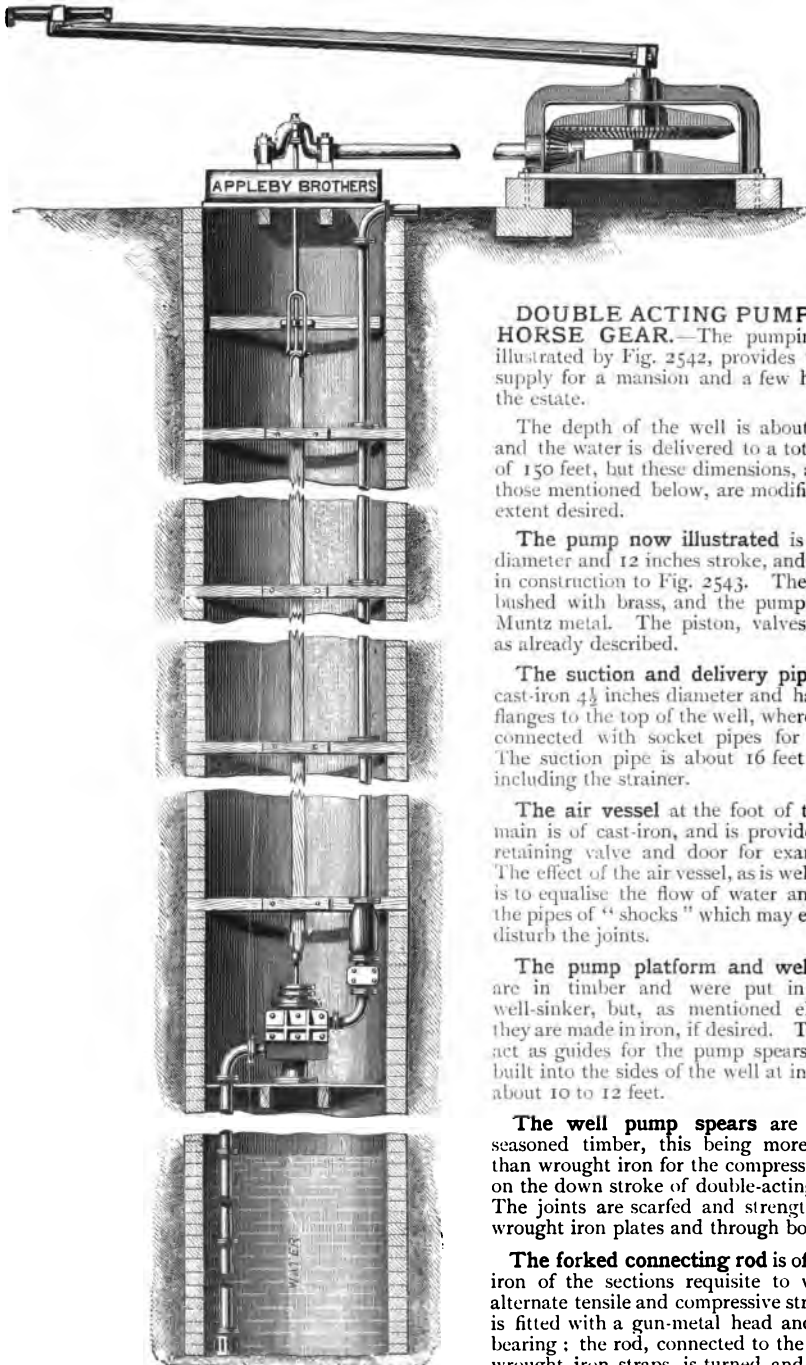
The pump rods are of wrought iron, with gun-metal heads, and are bored at the lower end to fit the piston rods ; by removing the cotter shown in the engraving any pump is stopped without interfering with the others.

Speed of working.—Owing to the nature of the liquids pumped the speed rarely exceeds 30 strokes per minute and this is adopted as a basis, some engineers, however, prefer to work at a lower speed and use larger pumps.

PRICES OF SETS OF THREE PUMPS WITH DRIVING GEAR, FIG. 2541.

Diameter of pump inches	3	4	5	6	8
Capacity, gallons each pump per hour ...	750	1800	2800	3800	8600
Price of set of pumps	£50	£60	£72	£85	£120
Diameter of pipes inches	2½	3	3½	4½	6

The cost of packing and delivery f.o.b. is about 5 per cent.



DOUBLE ACTING PUMP WITH HORSE GEAR.—The pumping plant, illustrated by Fig. 2542, provides the water supply for a mansion and a few houses on the estate.

The depth of the well is about 60 feet, and the water is delivered to a total height of 150 feet, but these dimensions, as well as those mentioned below, are modified to any extent desired.

The pump now illustrated is 6 inches diameter and 12 inches stroke, and is similar in construction to Fig. 2543. The barrel is bushed with brass, and the pump rod is of Muntz metal. The piston, valves, etc. are as already described.

The suction and delivery pipes are of cast-iron $4\frac{1}{2}$ inches diameter and have faced flanges to the top of the well, where they are connected with socket pipes for delivery. The suction pipe is about 16 feet over all, including the strainer.

The air vessel at the foot of the rising main is of cast-iron, and is provided with a retaining valve and door for examination. The effect of the air vessel, as is well known, is to equalise the flow of water and relieve the pipes of "shocks" which may eventually disturb the joints.

The pump platform and well stages are in timber and were put in by the well-sinker, but, as mentioned elsewhere, they are made in iron, if desired. The stages act as guides for the pump spears and are built into the sides of the well at intervals of about 10 to 12 feet.

The well pump spears are of well-seasoned timber, this being more suitable than wrought iron for the compressive strain on the down stroke of double-acting pumps. The joints are scarfed and strengthened by wrought iron plates and through bolts.

The forked connecting rod is of wrought iron of the sections requisite to withstand alternate tensile and compressive strains, and is fitted with a gun-metal head and bottom bearing: the rod, connected to the spear by wrought iron straps, is turned and works in a gun-metal guide.

Fig. 2542.

The well frame.—A strong cast iron plate, with bearings for the crank shaft, is fixed on timber beams or wrought iron girders, which span the top of the well; the crank shaft is of wrought iron and is driven by horse gear of the type referred to at pages 97 and 98 of Section I.

Driving by engine or other motor.—For this purpose the end of the crank shaft is fitted with belt pulleys or gear proportioned for running the pumps at the necessary speed. Another excellent mode of driving is by a Quadrant or "bob lever" which admits of the weight of the spears being balanced.

Information required for estimating is mentioned at page 4.

DOUBLE ACTING LIFT AND FORCE PUMPS.—Figs. 2535 to 2543 illustrate a few of the combinations of this compact and efficient type of pump and indicate that it may be fixed in any position desired, and be driven by gear, belt, messenger chain or in other convenient manner.

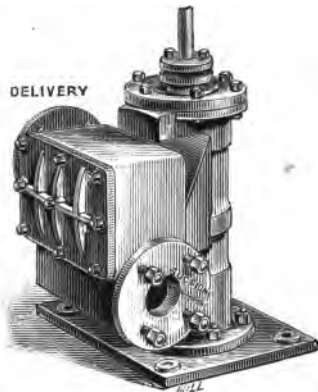


Fig. 2543.

The pump barrel is of close grained cast iron, truly bored and fitted with covers with faced joints and gland packings. The pump rod is of mild steel and the piston is provided with double cupped leathers carried in gun-metal bucket plates. The cost of brass lining is given in the following table.

The valve chest forms part of the pump, and contains a set of gun-metal valves of the grid type, with india-rubber discs secured by a single bolt. Complete access to the valves is obtained by removing the valve chest cover—the work of a few minutes.

The approximate duty in gallons per hour is obtained when the pump is in good working order and is run at a speed of about 40 strokes per minute.

Suction pipes, joints, etc., see notes, page 1. The prices of these and of Foot valves and other accessories are the same as for Centrifugal pumps, see page 78.

The prices are for pumps of standard dimensions and construction, to work vertically or horizontally. The position in which the pump is to be fixed should be clearly defined.

Information required. See notes at page 4.

PRICES OF DOUBLE ACTING LIFT AND FORCE PUMPS, Fig. 2543.

Diameter of pump inches	3	4	5	6	8	10	12
Stroke " " " "	10	12	12	12	14	14	15
Diameter of pipes "	2½	3	3½	4½	6	8	9
Capacity, gallons per hour ...	1150	2500	3800	5200	11500	17500	27500
Price of pump	£12	£13	£17	£21	£30	£42	£55
" " brass lined	£15	£17	£21	£27	£37	£51	£66
Extra for cast iron air vessel ..	25/-	30/-	35/-	45/-	55/-	65/-	75/-

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

VERTICAL FLY-WHEEL PUMPING ENGINES.

COLUMN STEAM PUMPS WITH FLY-WHEEL, illustrated by Figs. 2544 to 2547 (also known as "Cameron pumps") are largely and successfully used for innumerable purposes; and, as is well-known, are more economical in consumption of steam than direct acting pumps of other forms without fly-wheel.

The economy is principally due to the saving in steam by using it expansively, with very little clearance, and to the absence of irregularity in the length of stroke. The pumps are self-contained and can be regulated to work fast or slow, and every facility is provided for examination and maintenance of all working parts. The columns form air-vessels, and the flow is continuous in both suction and delivery pipes.

The engravings and descriptions are limited to the standard dimensions which can usually be delivered at short notice; but it will be understood that the proportions of steam cylinders and pumps must frequently be varied to adapt them for the duty required as regards steam pressures, high and low lifts, pumping semi-fluids, etc.

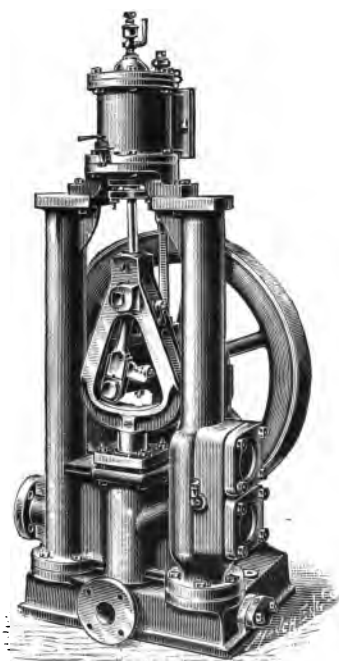


Fig. 2544.

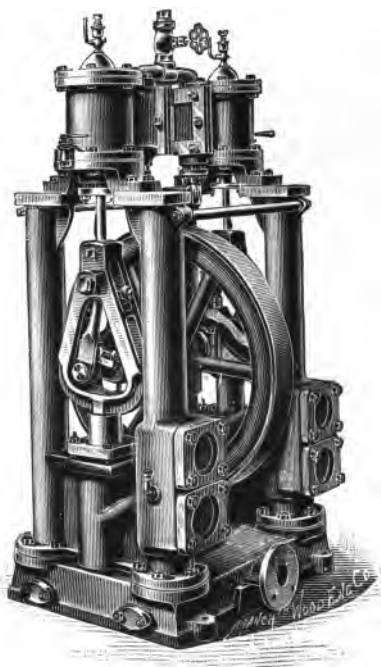


Fig. 2545.

SINGLE RAM AND CYLINDER COLUMN PUMP, illustrated by Fig. 2544, is adapted for working with steam pressures up to 80-lbs. per square inch; double pumps should be used for higher pressures.

General arrangement.—As will be seen, the pump and the columns which carry the steam cylinders are mounted on a cast iron base plate with flanged connections for the suction pipe. The columns (utilized as air vessels) are provided with covers which give access to the suction and delivery valves.

The steam cylinder is fitted with metallic packing, steel piston rod, steam stop valve, lubricators, etc. The crank shaft is of forged steel and the bearings for it and for the connecting rods are of gun-metal, and adjustable. The fly-wheel is of the proportions required to equalise the revolutions at whatever speed is desired and so maintain an even flow from the pumps.

The pump, fixed between the columns as shown is fitted with a deep gland easily packed; the plunger is secured to the lower end of the bow (or kite) connecting rod, the upper end of which is attached to the piston rod.

For pumping chemicals and other liquids the gland and surfaces of plunger are made in gun-metal; the extra cost of pumps so fitted is given in the following tables.

Tests.—All pumps are tested to the maximum duty, with steam and water, before delivery, and certificate of test is furnished, if desired.

PRICES OF COLUMN SINGLE CYLINDER AND RAM PUMPS, Fig. 2544.

Diameter of steam cylinder inches	4	5	6	6	7	7	7	8½
„ pump ram ... „	2	2½	3	3½	4	4½	5	6
Length of stroke ... „	3	4	5	5	6	6	6	8
Capacity, gallons per hour ...	260	400	670	900	1280	1600	2000	3200
For feeding boilers ... H.P.	15	25	40	55	75	100	125	200
Diameter of steam pipe ... inches	¾	1	1	1	1	1	1	1½
„ exhaust pipes ... „	¾	1	1	1	1½	1½	1½	2
„ water pipes ... „	1½	1½	2	2	3	3	3	3½
Price of pump, Fig. 2544 ...	£21	£25	£30	£34	£38	£43	£49	£62
„ „ gun-metal ram, etc.	£23.10	£27.10	£33.10	£38	£43	£49	£54	£68
Extra for governors ...	90/-	90/-	110/-	110/-	135/-	135/-	135/-	175/-

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

DOUBLE RAM AND DOUBLE CYLINDER COLUMN PUMPS.—Fig. 2545 are constructed as last described, but—the engines and pumps being in duplicate—the pumping capacity is double. They occupy very little more floor space than single pumps, and are to be preferred for the higher pressures.

PRICES OF COLUMN DOUBLE CYLINDER AND RAM PUMPS, Fig. 2545.

Diameter of steam cylinders, inches	4	5	6	6	7	7	7	8½	10
„ pump rams ... „	2	2½	3	3½	4	4½	5	6	7
Length of stroke ... „	3	4	5	5	6	6	6	8	9
Capacity, gallons per hour ...	520	800	1340	1800	2560	3200	4000	6400	8800
For feeding Boilers ... H.P.	30	50	80	110	150	200	250	400	600
Diam. steam & exhaust pipes, inches	¾	1	1	1	1½	1½	1½	2	2
„ water pipes ... „	1½	1½	2	2	3	3	3	4	4
Price of pump, Fig. 2545 ...	£34	£42	£51	£58	£64	£71	£77	£102	£134
„ „ gun-metal ram, etc.	£37	£47	£56	£62	£69	£77	£83	£110	£142
Extra for governors ...	90/-	90/-	110/-	110/-	135/-	135/-	135/-	175/-	200/-

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

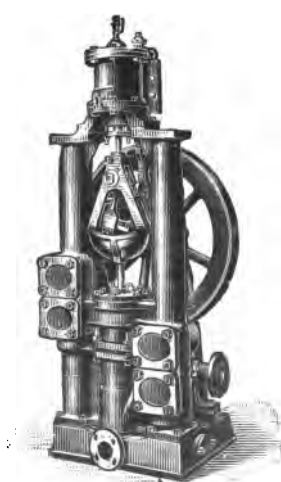


Fig. 2546.

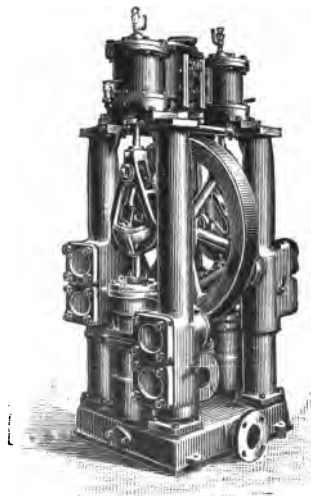


Fig. 2547.

COLUMN SINGLE CYLINDER AND DOUBLE ACTING PUMPS, Figs. 2546 and 2547.—The description of the pump, Fig. 2544, applies to those now illustrated, but the latter, being double acting, the duty is proportionately larger.

The **pump packing** is a feature to which special attention is directed. This is so arranged that the gland is packed externally with hemp or other packing. The leakage due to wear is external, and can be immediately detected; leakage between the upper and lower pump chambers is impossible.

The **continuous delivery** from double acting pumps is strongly in their favour for boiler feeding, and for other purposes where irregularity in flow is objectionable.

The **standard dimensions** given below can usually be supplied at short notice, but pumping machinery of this type is made of all capacities up to about 27,500 gallons per hour.

PRICES OF COLUMN DOUBLE ACTING PUMPS, FIG. 2546.

Capacity, gallons per hour	240	440	800	1200	1700	2300	2950	3750	5900
Price of pump	£17	£26	£31	£39	£42	£51	£57	£62	£85

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

COLUMN DOUBLE CYLINDER AND QUADRUPLE ACTING PUMPS, illustrated by Fig. 2547, are made of all capacities up to about 60,000 gallons per hour and used for the high pressures required for boiler feeding, town water supply, as stationary fire engines, etc.

Each of the two steam cylinders drives a double acting pump which has all the facilities last referred to for maintenance in efficient working order.

PRICES OF COLUMN DOUBLE CYLINDER QUADRUPLE ACTING PUMPS.

Capacity, galls. per hour	480	890	1600	2400	3350	4600	5900	7500	11800
Price of pump	£29	£46	£51	£62	£69	£85	£97	£108	£154

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

Column double and quadruple acting pumps.—Figs. 2546 and 2547, for lifting respectively up to 60 and 120 feet, are made as described at page 52, and of all capacities up to about 80,000 gallons per hour, the dimensions of engines and pumps being modified to suit the duties specified.

PRICES OF COLUMN SINGLE CYLINDER DOUBLE ACTING PUMPS, FIG. 2546.

Capacity, galls. per hour	700	1000	1500	2000	2700	3500	4200	5500	9500
Price of pump for 60-ft. lift	£26	£29	£37	£44	£52	£55	£66	£69	£96
„ „ for 120 „	£28	£33	£41	£47	£54	£58	£72	£83	£114

PRICES OF COLUMN DOUBLE CYLINDER QUADRUPLE ACTING PUMPS, FIG. 2547.

Capacity, galls. per hour	1400	2000	4200	7500	8500	11000	19000	25000	30000
Price of pump for 60-ft. lift	£46	£52	£74	£98	£108	£120	£170	£228	£250
„ „ for 120 „	£50	£57	£77	£100	£120	£150	£215	£263	£275

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

COLUMN SINGLE CYLINDER AND DOUBLE ACTING PUMP WITH BOILER.—The pumps, Fig. 2546, and a vertical cross tube boiler are carried on a neat cast-iron base plate in the manner indicated in Fig. 2553, complete with all usual fittings and pipe connections between the steam cylinder and boiler.

Pumps for low lifts, not exceeding about 60 feet, cost from 5 to about 10 per cent. less than pumps of equal capacity when working with 120 feet lift.

PRICES OF SINGLE CYLINDER AND DOUBLE ACTING PUMPS WITH BOILER.

Capacity, gallons per hour ...	700	1100	1500	2100	3760	5900	8000	10200
Price of pump for 120 feet lift	£69	£75	£87	£92	£116	£166	£180	£200
" " 200 "	£77	£91	£98	£115	£153	£198	£217	£255

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

COLUMN SINGLE CYLINDER DOUBLE ACTING BALLAST PUMPS as represented by Fig. 2546 are specially constructed for working at high speed, with a low consumption of steam, and are entirely self-contained.

The columns act as air vessels on the delivery side, and an air vessel is provided for the suction side. The crank shaft and connecting rod bearings are of gun-metal, and adjustable, and the steam cylinder is fitted with steam stop valve, lubricator, etc.

PRICES OF COLUMN SINGLE CYLINDER DOUBLE ACTING BALLAST PUMPS, Fig. 2546.

Capacity per hour tons	45	60	95	120	150	170	240
Prices of pump... ..	£65	£85	£110	£135	£160	£195	£260

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

DIRECT ACTING STEAM PUMPS WITH FLY WHEEL.—Reference is made at page 52, to the economy obtained by using steam expansively and with small cylinder clearances. These results, together with complete accessibility to valves and working parts, are attained by the standard steam pumps, illustrated by Figs. 2548 and 2549 which have, for many years, been largely and successfully used under very varied conditions.

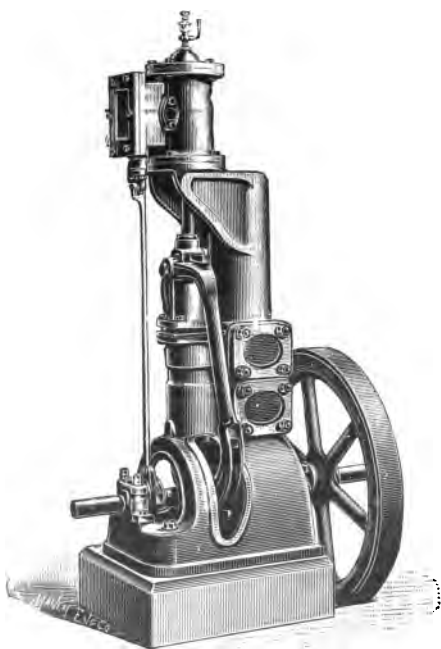


Fig. 2548.

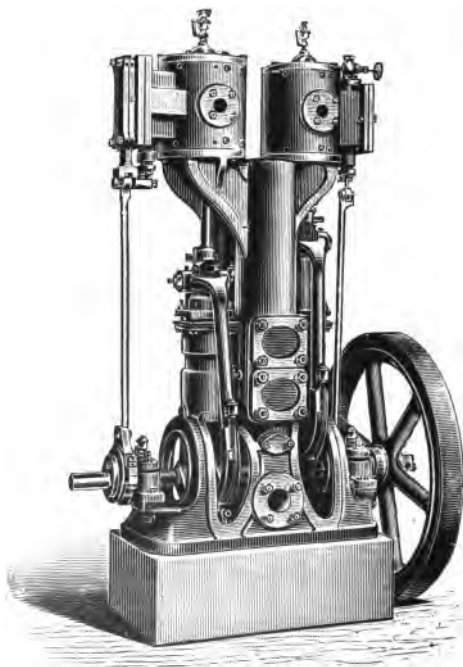


Fig. 2549.

STANDARD DIRECT ACTING STEAM PUMPS.—Figs. 2548 and 2549 represent single and double pumps largely used for most purposes for which steam pumps can be employed, such as feeding boilers, water supply, drainage, pumping tar and other viscid liquids.

The construction is sufficiently indicated in the engravings and it will only be necessary to point out that the standard for both single and double pumps forms an air-vessel, which equalises the flow from the pumps.

Single cylinder pumps are quite satisfactory for feeding boilers working at pressures not exceeding about 75 lbs. per square inch, or for a vertical lift of 170 feet, but double pumps are preferable if those limits are exceeded.

The **steam cylinders**, carried on brackets at the top of the standard, are fitted with metallically packed pistons, steel piston rods, lubricators, etc. The air vessel in the standard is provided with doors for access to both sets of valves.

The **crank shaft** is of forged steel; the bearings are of gun-metal with loose caps, lock nuts and lubricators, the whole being mounted on a strong cast-iron base plate.

Pumps.—The plungers are fitted to the piston rods and form efficient guides for the engine; the pumps are driven from the crank shaft by the bow or "Kite" connecting rods shown in the engraving.

The **fly-wheel** is of the weight and dimensions required to equalise the revolutions of the crank shaft of either single or double cylinder pumping engines, at whatever speed it may be desired to run them.

Governors are not usually required for pumping engines, but they can be fitted to either the single or double pumps at the extra cost given below.

Dimensions.—The following tables give most (but not all) of the sizes and combinations in which these pumps are made.

PRICES OF SINGLE CYLINDER STANDARD STEAM PUMPS, Fig. 2548.

Diam. of steam cylinder	... inches	4	5	5½	6	6½	7	7
" ram	... ..	2	2½	3	3½	4	4½	5
Length of stroke	... ..	4	5	6	7	8	9	10
Capacity, galls. per hour	... ..	475	750	1050	1450	1900	2400	3300
For feeding boilers	... H.P.	30	48	65	90	120	155	213
Diam. of steam pipe	... inch.	3/8	½	½	¾	¾	1	1
" exhaust,	... ..	3/4	1	1	1½	1½	1½	1½
" water pipes	... ..	1½	2	2	3	3½	3½	4
Price of pump	... ..	£22	£25	£30	£35	£41	£47	£54
Extra for governors	... ..	90/-	90/-	110/-	110/-	135/-	135/-	135/-

PRICES OF DOUBLE CYLINDER STANDARD STEAM PUMPS, Fig. 2549.

Diam. of steam cylinder	inches	6	6½	7	8½	10	12	14	16
" rams	... ..	3½	4	5	6	7	8	9	10
Length of stroke	... ..	7	8	10	12	14	16	16	16
Capacity, galls. per hour	... ..	2900	3800	6650	10000	14750	20450	25800	29200
For feeding boilers	... H.P.	185	240	425	640	945	1300	1620	1870
Diam. of steam pipe	... inch	1½	1½	1½	2	2½	3	3½	4
" exhaust,	... ..	1½	1½	1½	2	2½	3	3½	4
" water pipes	... ..	3	3½	4	5	6	7	7	8
Price of pump	... ..	£62	£71	£96	£130	£165	£225	£287	£332
Extra for governors	... ..	£5	£6	£7	£8	£9	£10	£12	£14

DUPLEX & DIRECT ACTING STEAM PUMPS.

DUPLEX DIRECT ACTING STEAM PUMPS of the types represented by Figs. 2550 to 2552 are perhaps less economical in consumption of steam than those with fly wheels last referred to, but this construction affords such facilities for varying the proportions of engines and pumps to adapt them to the duty to be performed, that thousands of them are in use under conditions varying from town water service, main drainage and hydraulic pressure supply, to Donkey pumps for feeding boilers, for pumping Ballast, circulating water for Condensers and similar purposes.

Compound and triple expansion pumping engines are arranged to work horizontally or vertically, with or without condenser, but it is impossible in the space available to do more than illustrate and describe the standard high pressure non-condensing types and dimensions.

In all cases the motion of one piston rod operates the slide valve which controls the admission of steam to the neighbouring cylinder, so that the pump will start work at any part of the stroke.

High pressure pumps have the proportions required for working with the highest pressures as boiler feeders, and for forcing water for other purposes to heights proportionate with the steam pressure available.

The low pressure pumps are used in connection with Surface Condensers, for pumping ballast and raising water to a moderate height.

The pumping capacity given in the following tables may be regarded as the maximum average for continuous service, but it may be largely exceeded in emergencies.

Water heating.—A sensible economy is effected by utilizing the exhaust steam for heating the feed water, *vide* pages 3 and 47 of Section I. of this series.

Designs and estimates for pumping plant differing from that now referred to can be prepared if information is supplied (substantially) as indicated at page 4.

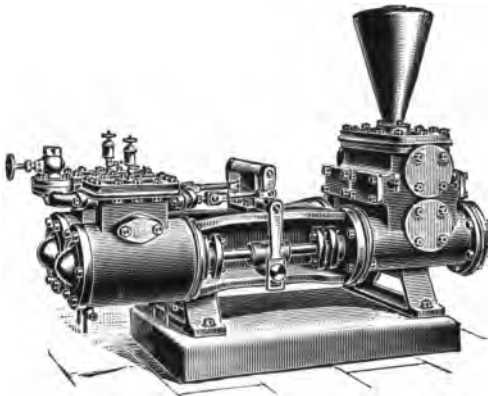


Fig. 2550.



Fig. 2551.

HORIZONTAL AND VERTICAL HIGH PRESSURE DUPLEX PUMPS.

—Figs. 2550 and 2551 illustrate pumping engines of the high pressure type above referred to for all capacities up to about 50,000 gallons per hour.

The engines and pumps are of ample proportions and are designed to afford complete facility for examination and maintenance. The valve gears of the engines are of hardened steel, the steam cylinders are neatly clothed and fitted with steam stop valve, drain cocks, lubricators, etc., and covers are provided for access to the pump suction and delivery valves.

PRICES OF HORIZONTAL AND VERTICAL HIGH PRESSURE DUPLEX PUMPS, FIGS. 2550 AND 2551.

Diameter of steam cylinder, inches	3	4½	5½	6	7	10	12	12	14
" " pump "	2	2½	3½	4	5	6	7	8	9
Length of stroke ... "	3	4	5	6	6	8	10	10	10
Capacity, gallons per hour ...	500	1200	2500	3800	6000	10000	14000	18000	25000
Diameter of steam pipe ... inches	½	½	¾	1½	1½	2	2½	2½	2½
" exhaust pipe "	¾	1	1½	1½	2	2½	2½	2½	3
" water pipes "	1	1½	2½	3	3½	4	5	6	7
Price of horizontal pump, Fig. 2550	£21	£26	£43	£51	£71	£92	£124	£160	£173
" vertical pump, Fig. 2551	£23	£34	£51	£62	£83	£112	£150	£193	£240

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

HORIZONTAL AND VERTICAL LOW PRESSURE DUPLEX PUMPS are constructed as indicated in Figs. 2550 and 2551, the dimensions of steam cylinders and pumps being modified to suit the lower duty required for circulating water in condensers, pumping water ballast, etc.

For marine purposes gun-metal is used for the working parts of the pump, and the suction and delivery pipe connections can be made on either side, as desired.

PRICES OF HORIZONTAL AND VERTICAL LOW PRESSURE DUPLEX PUMPS, Figs. 2550 & 2551.

Capacity, tons per hour ... about	40	60	80	100	120	160	200
Diameter of steam pipe ... inches	$\frac{3}{4}$	$\frac{3}{4}$	1	1	2	2	2
„ exhaust pipe ... „	1	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$
„ water pipes ... „	3 $\frac{1}{2}$	4	5	6	7	8	8
Price of horizontal pump ... „	£57	£97	£103	£114	£137	£171	£205
„ vertical ... „	£46	£57	£92	£114	£124	£183	£230

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

DOUBLE ACTING DUPLEX PUMPS WITH EXTERNAL PACKING.

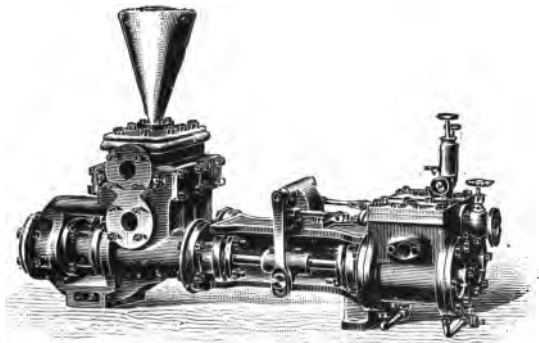


Fig. 2552.

Fig. 2552 represents horizontal double acting pumps for high pressures which occupy little more space than the single acting pumps Figs. 2550 and 2551, but are of much higher pumping capacity. The improved external ram packing provides complete facility for maintenance and renders impossible the unseen leakage which is frequently a source of loss in the useful effect of piston pumps.

Vertical pumps with external packing resemble Fig. 2551 so closely in general arrangement, that the following leading dimensions and prices will answer every purpose without further illustration.

PRICES OF DOUBLE ACTING DUPLEX PUMPS WITH EXTERNAL PACKING.

Capacity, gallons per hour ...	890	1600	3350	4600	7500	11800	16500	21600
Diameter of steam pipe, inches	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2	2	2
„ exhaust „ „	$\frac{3}{4}$	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2	2 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$
„ water pipes „	1	1 $\frac{1}{2}$	2 $\frac{1}{2}$	3	3 $\frac{1}{2}$	4	5	6
Price of horizontal pump ...	£28	£36	£51	£63	£80	£103	£142	£177
„ vertical ...	£32	£40	£65	£80	£105	£142	£194	£245

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

DUPLEX COMBINED AIR AND CIRCULATING PUMPS occupy little space and take the place, for this duty, of pumps driven by the main engines. The advantage of this arrangement is that a vacuum is established before the main engines are started and they are relieved from the work done by these (separate) pumps.

The standard dimensions of these pumps are given below, but other proportions are made to suit the duty to be performed.

The pumps are lined with gun-metal and the water pumps have gun-metal pistons, piston rods, valves and valve seats.

PRICES OF DUPLEX COMBINED AIR AND CIRCULATING PUMPS.

Diameter of steam cylinder inches	3½	5	6	8
„ circulating pump „	3½	4½	5½	7
„ air pump „	3½	5½	6½	8½
Price of combined pump	£50	£70	£100	£140

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

HORIZONTAL DUPLEX STEAM PUMPS WITH BOILER.—Fig. 2553 represents a complete pumping plant, mounted on a wrought iron base plate, for use where the arrangement must be as compact as possible, and steam cannot conveniently be supplied from an existing boiler.

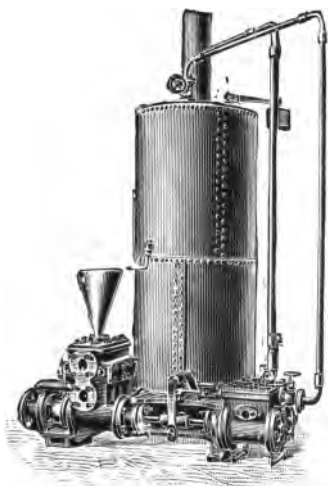


Fig. 2553.

The duplex pump is of the type Fig. 2550, with externally packed ram, or with piston pump, Fig. 2552, which are constructed as described at pages 57 and 58.

The vertical boiler is constructed of mild steel plates, with internal fire box, cross tubes and uptake, as illustrated at page 34 (Fig. 1530) of Section I. of this series, and is complete with all furnace, steam and feed water fittings, including an injector. The proportions are ample for the duty specified when fired with English (or equal quality) coal.

The dimensions of pumps, engines, pipes, etc. are given at pages 57 and 58, and need not be repeated, but the relative approximate duties are now given as a guide in determining the size and type to be adopted.

Fuel.—The boilers have the grate and heating surfaces required for working with good coal. If the fuel to be used is inferior in heating properties, its character and calorific value should be stated in order that the necessary surfaces may be provided and the extra cost thereof ascertained.

PRICES OF HORIZONTAL DUPLEX PUMPS, FIG. 2550, WITH BOILER, ETC.

Capacity, gallons per hour ...	500	1200	1800	2500	3800	6000	10000	14000
Price of plant for 80 feet lift ...	£64	£73	£77	£85	£91	£107	£137	£148
„ „ 120 „ ...	£64	£75	£89	£97	£107	£140	£160	£190
„ „ 200 „ ...	£65	£76	£100	£110	£130	£165	£210	...

PRICES OF HORIZONTAL DUPLEX PUMPS, FIG. 2552, WITH BOILER, ETC.

Capacity, gallons per hour ...	800	1900	2400	3350	4600	5900	7500
Price of plant for 80 feet lift ...	£80	£88	£93	£100	£110	£114	£125
„ „ 120 „ ...	£80	£90	£100	£110	£124	£132	£155
„ „ 200 „ ...	£80	£91	£110	£123	£148	£166	£182

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

PORTABLE DUPLEX PUMPING PLANT is arranged as indicated in Fig. 2553, but the base plate carrying the pumps and boiler is mounted on wrought iron axles, with plain or flanged wheels and appliances of the kind required for haulage.

The extra cost varies from about £7 to £20.

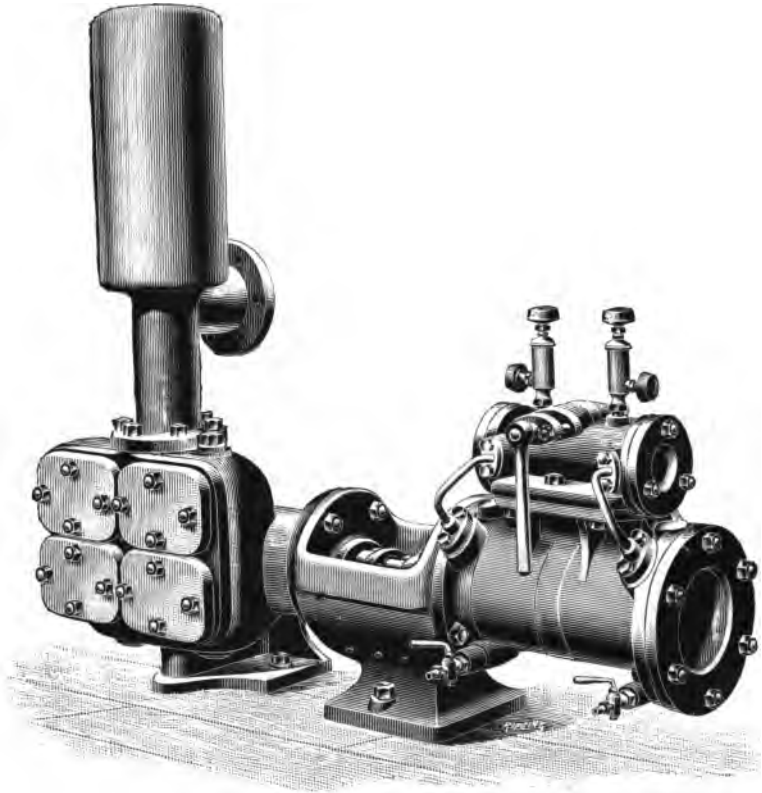


Fig. 2554.

SINGLE CYLINDER DIRECT ACTING STEAM PUMP.—Fig. 2554 represents a type which although not the most economical in consumption of steam, is much used for boiler feeding and many other purposes; the relative proportions of steam cylinder and pump are varied almost indefinitely to suit any given steam pressure, pumping capacity, and height of lift.

These pumps are available for draining open workings, as indicated in Fig. 2552, or for unwatering mines during the time the permanent pumps are being put down, or where continuous pumping is not necessary.

The work performed is (naturally) in proportion with the speed of working, the quantities stated are delivered when the piston speed is not less than 75 feet per minute.

The prices of standard sizes of these pumps, with iron and brass lined barrels and gun-metal ram are as follows:

PRICES OF SINGLE CYLINDER DIRECT ACTING PUMPS.

Diameter of steam cylinder ... inches	5	6	7	8	9	10	10
„ water „ ... „	2½	3	4	5	6	7	8
Length of stroke ... „	12	12	12	12	12	12	12
Capacity, gallons per hour ... „	950	1350	2400	3200	6000	7450	9750
Diam. of steam pipe ... inch.	¾	¾	1	1½	1½	1½	1½
„ exhaust pipe ... „	1	1	1½	1½	2	2	2
„ suction and delivery pipe „	2	2½	3	3½	4½	5	6
Price of pump ... iron barrel	£17	£20	£25	£31	£38	£47	£53
„ „ „ brass lined, etc.	£19	£22	£29	£35	£46	£54	£62

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

VERTICAL DIRECT ACTING STEAM PUMPS are constructed on the same principle as Fig. 2554, and with as great variations in proportions, for use in mine shafts, wells, or where floor space is restricted.

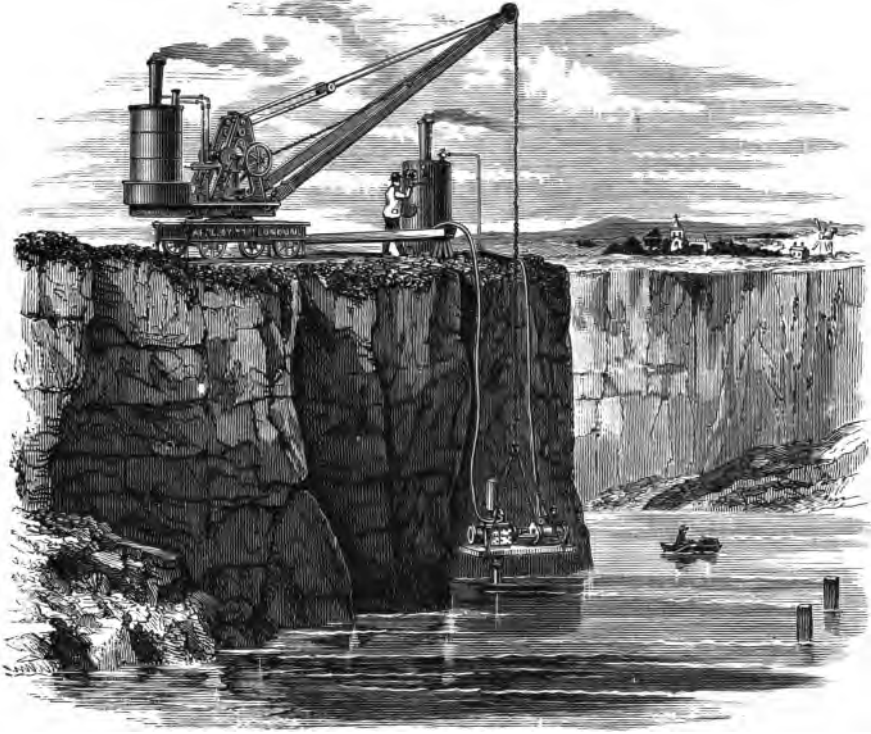


Fig. 2555.

DIRECT ACTING STEAM PUMPS FOR DRAINAGE.—The engraving, Fig. 2555, illustrates one of many arrangements for working these pumps for drainage purposes.

The crane is ordinarily used for handling the granite when quarried, but when the workings are flooded after heavy rains, its services are not required for that purpose. The platform on which the pump is fixed is then suspended, and is lowered by the crane as the workings are unwatered, so that the immersion of the suction pipe remains at about the same depth from the surface of the water.

DIRECT ACTING PUMP WITH BOILER AND PIPES.—If a complete installation is required including pump and boiler of ample capacity, together with steam and feed water fittings, steam and water delivery pipes, platform for pump with sling chains and all accessories, ready for lowering and commencing work, information on the following details should be furnished.

A sketch showing the position in which the pump must work and the manner in which the pipes will most conveniently be carried, with the necessary figured dimensions.

The quantity of water to be raised in a given time should be clearly defined, also :

The height from water level to the point of discharge, with length of pipe (if any) required.

The character of fuel and water to be used for raising steam, if either are of exceptional quality.

If a sketch cannot be sent, the above-named details should be accurately described.

DONKEY AND FEED PUMPS.



Fig. 2556.



Fig. 2557.

SINGLE AND DOUBLE ACTING STEAM DONKEY PUMPS.—

Figs. 2556 and 2557 represent the well-known compact donkey pump to fix to a boiler, wall, bulk head or post for use in feeding boilers and for raising water or other liquids. The under-named combinations of size of steam cylinder and pump are the standard dimensions for feeding boilers working at ordinary pressures.

The pumping capacity, of course, depends on the number of revolutions made. The approximate quantities specified are delivered when the pumps are properly maintained, and are worked at about the maximum speed.

Tests and accessories.—Each pump is tested to its full duty, and is sent, if desired, with the requisite pipes and connections ready to fix, provided that the latter are clearly defined by sketch or otherwise. These are charged at current rates for such fittings.

DOUBLE ACTING STEAM DONKEY PUMPS, of the type Fig. 2556, are completely accessible for examination, and the flanges for steam, exhaust, suction, and delivery pipes are, respectively, interchangeable to admit of these connections being carried in the direction most convenient. The casting to which the steam cylinder is fixed forms an air vessel on the delivery side.

The steam cylinder is provided with stop valve and lubricator; the pump ram, gland, valves, valve seats and bearings are of gun-metal, and the latter are adjustable.

PRICES OF DOUBLE ACTING STEAM PUMPS, Fig. 2556.

Diam. of steam cylinder inches	3	4	5	6	6	7	7	7
„ pump	1½	2	2½	3	3½	4	4½	5
Length of stroke	3	4	5	6	6	6	6	6
Capacity, gallons per hour ...	420	800	1250	1820	2160	2560	3200	4000
For boilers H.P.	25	50	80	100	140	160	200	250
Diam. of steam pipe ... inches	½	¾	1	1½	1½	2	2½	3
„ exhaust pipe	½	¾	1	1	1	1½	1½	1½
„ water pipes	1	1½	1½	2	2	3	3	3
Price of pump	£18	£24	£31	£34	£38	£46	£51	£57

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

SINGLE ACTING STEAM PUMPS, Fig. 2556, are similar in construction to those last referred to, excepting that they are single instead of double acting.

The ram is of gun-metal, packed externally so that the duty mentioned is easily maintained. The crank shaft and connecting rod bearings are of gun-metal and adjustable.

PRICES OF SINGLE ACTING STEAM PUMPS, Fig. 2556.

Diam. of steam cylinder inches	2	2½	3	4	5	5½	6½	7
„ ram	1	1½	1½	2	2½	3	4	5
Length of stroke	2	2½	3	4	5	6	6	6
Capacity, gallons per hour ...	90	130	210	400	625	910	1280	2000
For boilers H. P.	5	8	13	25	38	56	80	125
Diam. of steam pipe ... inches	¾	1	1	1½	1½	2	2½	3
„ exhaust pipe	¾	1	1	1½	1½	2	2½	3
„ water pipes	1	1	1	1½	1½	2	2½	3
Price of pump	£8	£10	£15	£18	£23	£27	£34	£39

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

SINGLE ACTING STEAM PUMPS, Fig. 2557, fulfil the same conditions as those last referred to, but the base of the standard which carries the pump is adapted for bolting to timber or masonry. As indicated in the engraving, the fly wheel is outside and can be fitted with a handle for working by manual power when desired.

PRICES OF SINGLE ACTING STEAM PUMPS, Fig. 2557.

Diameter of steam cylinder, inches	1½	2½	3	3½	4½	4½
„ ram	¾	1½	1½	2	2½	2½
Length of stroke	1	2½	3	3	4	4
Capacity, gallons per hour ...	30	125	180	300	400	500
„ for boilers of nom. H. P.	2	8	12	20	25	30
Price of pump	£4	£9	£10	£12	£15	£17
„ extra for hand power ...	2/-	3/-	4/-	4/-	5/-	5/-

The cost of packing and delivery f.o.b. is 5 per cent.

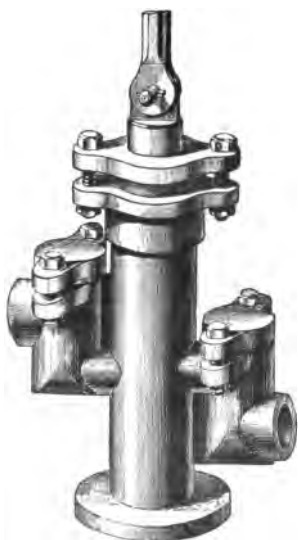


Fig. 2558.

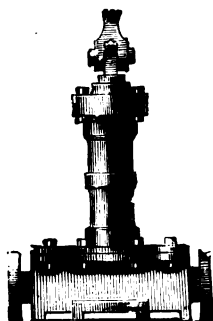


Fig. 2559.



Fig. 2560.

RAM OR PLUNGER PUMPS.—Fig. 2558 and 2559 represent useful types of pumps for feeding boilers and raising all kinds of liquids. The rams, barrels and valves are made of the metals suitable for the liquids to be dealt with, and are arranged to work vertically, horizontally, or in other convenient position.

CRANK DRIVEN RAM PUMPS.—Figs. 2558 and 2559 are provided with a jointed rod end for connecting with the rod to the crank, disc plate, or eccentric. If a variable supply is desired, the connecting rod can be provided with a sleeve and cotter, whereby the length of stroke can be adjusted, or the pump put out of work without stopping the driving shaft.

PRICES OF CRANK DRIVEN RAM PUMPS, Fig. 2558.

Diameter of ram inches	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Price of pump in iron	£2 10	£2 10	£3 10	£5	£6 10
„ gun-metal ram and valve ...	£2 10	£3 10	£4 10	£6	£8 10

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

PRICES OF CRANK DRIVEN RAM PUMPS, Fig. 2559.

Diameter of ram ... inches	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4
Price of pump	£2	£2 10	£3 10	£4 10	£6	£7 10	£9

HAND POWER RAM PUMPS, similar to Fig. 2558, are made up to 2 inches diameter, with a standard and lever for working by hand power, at an extra cost of about £1 10s.

BELT DRIVEN RAM PUMPS, Fig. 2560, are adapted for fixing to a wall, column, or post, and are fitted with fast and loose pulleys, gun-metal valves, and seats and door for access to them.

Larger sizes than those referred to are mounted on a base-plate and are self-contained.

PRICES OF BELT DRIVEN RAM PUMPS, Fig. 2560.

Diameter of ram inches	$1\frac{1}{2}$	2	$2\frac{1}{2}$
„ water pipes	$\frac{3}{4}$	1	$1\frac{1}{4}$
Capacity, gallons per hour ...	160	280	450
Price of pump	£4	£5	£6

GLOBULAR FOOT VALVES AND STRAINERS for pump and injector suction pipes are made in gun-metal, with perforations exceeding in sectional area that of the suction pipe; the stem is screwed for wrought iron tube.

PRICES OF GUN-METAL FOOT VALVES AND STRAINERS.

Diameter of pipe inches	1	$1\frac{1}{2}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
„ strainer	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4
Price of foot valve	3/6	5/3	7/	11/	18/
„ strainer	2/9	4/	4/6	6/6	10/6
„ foot valve and strainer ...	6/3	9/3	11/6	17/6	28/6

RAM PUMPS WITH TRUNK PLUNGERS and externally packed glands are adapted for lifting and forcing water or other liquids, sewage, tar, oils, etc.

The ram is of gun-metal, and a door is provided for access to the valves. The pumps are made up to almost any size and can be arranged as double or treble barrel with driving gear, connecting rods, etc. as used for pumps, Fig. 2541.

PRICES OF TRUNK PLUNGER RAM PUMPS.

Diameter of ram inches	3	4	5	6
Price of pump	£8	£9	£10	£11

STONEWARE RAM PUMPS, on the same principle as those above illustrated and described, are made in vitrified stoneware for lifting and forcing acids, alkalies, vinegar, etc.

The working parts are carefully ground and fitted and the valves are adjustable and quite easy of access. The pumps are tested to a pressure equivalent to 30 feet head. Flanged connections are provided for the suction and delivery pipes; the prices of these with faced flanges will be found below, also the cost of the spare fittings usually required for renewals.

PRICES OF STONEWARE RAM PUMPS.

Diameter of ram inches	2	3	4
Length of stroke "	8	10	12
Capacity, gallons per hour	240	600	1250
Price of pump	£7	£9	£11
„ flanged pipes per foot	2/6	3/-	3/9
„ spare fittings	£1 10	£2	£2 10

The cost of packing for shipment and delivery f.o.b. averages about 5 per cent.

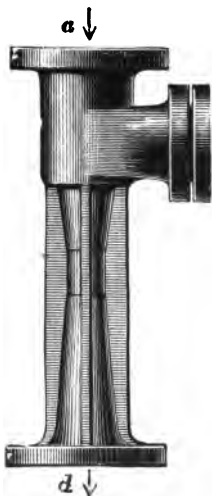


Fig. 2561.

STEAM JET ELEVATORS

to raise or circulate water, chemical or other liquids, including those highly charged with gritty or flocculent matter, are represented by Fig. 2561 for flanged, and Fig. 2562 for screwed pipe connections

The elevators can be had in the various metals mentioned below to adapt them for raising or agitating most chemical solutions and of any desired capacity. Those now referred to are to force only, but they are arranged to lift and force, provided that proper information is given as to the steam pressure available, the specific gravity and temperature of the liquor, and the heights of lift and force.

The duty of a Steam Jet Elevator, in height of lift, is in proportion with the pressure per square inch of steam and is approximately as follows :

Steam pressure, lbs.	15	30	45	60	75
Height lifted, feet	15	40	65	90	120



Fig. 2562.

but they can be constructed to lift to four times the height with the same steam pressure. They may be fixed vertically or horizontally and the best result is obtained when they are fixed below the level of the liquid to be raised.

The volume of liquid raised is increased by the condensation of steam from about $\frac{1}{4}$ to 2 per cent. according to the height of lift, and the temperature of the liquid is increased from about 5° to 30° F.

PRICES OF STEAM JET ELEVATORS WITH FLANGES, Fig. 2561.

Capacity, gallons per hour ...	120	240	540	900	1500	2100	3000	6000
Diameter of steam pipe inches	$\frac{1}{2}$	$\frac{3}{4}$	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2	2 $\frac{1}{2}$
„ suction and delivery „	$\frac{1}{2}$	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$	2	2	2 $\frac{1}{2}$	3
Price in cast iron	£1 10	£2 5	£2 10	£3	£4	£5	£6	£8
„ brass	£2	£3	£3 15	£4 5	£5	£6	£8	£11
„ lead	£1 10	£2 10	£3	£3 10	£4 10	£5 10	£7	£10
„ iron lead lined ... ..	...	£1 10	£1 15	£2 10	£3 10	£4	...	...
Copper suction filter	10/-	16/-	18/-	20/-	25/-	28/-	35/-	40/-

PRICES OF STEAM JET ELEVATORS WITH SCREWED ENDS, Fig. 2562.

Capacity, gallons per hour	120	240	540	900	1500
Diameter of steam pipe inches	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{2}$	1
„ suction and delivery „	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$
Price in cast iron	£1 5	£2	£2 5	£2 10	£3 10
„ brass	£1 10	£2 10	£3	£3 10	£4

PORCELAIN STEAM JET ELEVATORS for lifting and distributing strong acids, lyes, etc. are made with iron flanges so arranged that the liquors do not come into contact with the outside of the pipes.

PRICES OF PORCELAIN STEAM JET ELEVATORS.

Capacity, gallons per hour	250	600	1000	1600	2500
Diameter of steam pipe inches	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{2}$
„ suction and delivery „	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	2
Price with iron flange and bolts „	£5	£6	£7	£8	£9

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

INJECTORS.—Although many modifications of these most useful instruments have been introduced within the last few years there is but little difference in the principles of their construction; the causes of uncertainty in the action of the earlier forms of injectors have been so completely removed that those now referred to may be entrusted to any driver. Attention is also directed to the fact—well known, but not always recognised—that the steam used in forcing the water into the boiler imparts its heat to the feed water and so effects a proportionate saving in the consumption of fuel.

The injector, Fig. 2563, is of class **A** type referred to in the list on the following page; the others—for which prices are given—vary from it in details but not sufficiently so to make it necessary that each class should be illustrated. Thus classes **H** and **I** have self-contained steam valve and back pressure valve, whilst **A** and **B** have the former but not the latter. The injector costs less than a pump to deliver a corresponding quantity, and having no parts in motion the wear and tear is very small and, as it is entirely independent of the engine, the boiler can be fed whilst the engine is standing, which is often a great convenience. The steam employed in working the injector is returned to the boiler in a condensed form, with the feed water, raising its temperature and tending to prevent unequal expansion.

Fixing injectors.—Care should be taken that the pipes connecting the injector with the boiler should not be of smaller diameter than that mentioned in the lists. Injectors **H** and **A** may be placed above or below the water supply, but **I** and **B** must be below or on the same level. They may be fixed either horizontally or vertically. The nut of the water regulating wheel must be kept moderately tight, to prevent the wheel being accidentally moved from its proper place. The water supply pipe should have a rose on the end of it, and care must be taken that this pipe is air tight. As an extra precaution, a back pressure valve should be placed on the delivery pipe, between the injector and boiler, also a regulating valve on the steam supply pipe; the latter is a necessity in class **I**. When it is desired to start feeding, open the valves or cock connecting the injector with the boiler, then open the water supply pipe to the extent required by the pressure in the boiler. The quantity of water fed may be increased by opening both the steam and water supplies.

Prices of Injectors in general use, and directions for ascertaining the size required, are given on the following page.

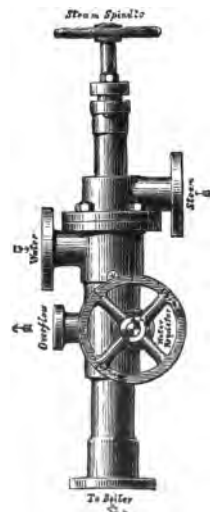


Fig. 2563.

PRICES OF INJECTORS, Fig. 2563.

Number or size in Millimetres.			PRICES.										NUMBER OF GALLONS DELIVERED PER HOUR AT THE UNDERNAMED STEAM PRESSURES.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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The nominal horse power of stationary boilers, fed with fresh water which the Injector will supply, is found by omitting the last figure in the above table of gallons, thus:—

A number 6 Injector with 80-lbs. steam pressure will feed a boiler of 64 nominal horse power, or one of 50 horse power with 50-lbs. steam pressure; and so on.

For Marine boilers fed with sea water the Injector should be one or two sizes larger, to allow the margin necessary for blowing off brine, etc. For description of the different types of Injectors, see the preceding page. The cost of packing for shipment and delivery f.o.b. is 5 per cent.

THE UNIVERSAL INJECTOR, Fig. 2564, works with steam at any pressure between 5 lbs. and 150 lbs. per square inch and (if necessary) will lift cold feed water from a depth not exceeding 24 feet or—with an overhead supply—any of these injectors will feed water at temperatures up to 150 degrees.

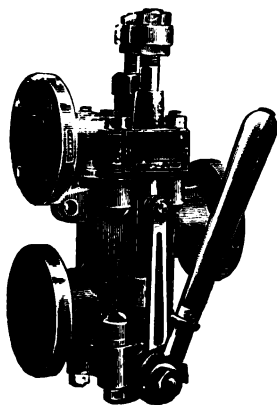


Fig. 2564.

Fig. 2564 represents what is called a "right hand" injector, that is to connect with the boiler on right, but the branches are reversed for fixing to the opposite side, and either right or left hand will be sent as may be required. If orders are cabled, the word "right" or "left" before or after the code word given in the index will suffice to insure correct execution.

If injectors are required to fulfil conditions differing from those referred to in this description and the accompanying list, the points of deviation should be specified and, in all cases open to doubt, it is desirable that information should (if possible) be given as to the working pressure of steam, the temperature of the feed water and the quantity required per hour; also the height of lift (if any) or the height in feet of the feed water supply above the point of delivery to the boiler.

The duty, given in the following table, in gallons delivered per hour, is based on a steam pressure of 60 lbs. per square inch.

If loose flanges are required the extra cost, including bolts, is about 10 per cent. Injectors with brass cases are made with unions and those in iron, with flanges as shown.

Special quotations will be given for injectors of larger capacity than 1250 gallons per hour.

PRICES OF UNIVERSAL INJECTORS, Fig. 2564.

Capacity, gallons per hour	92	164	260	370	510	660	830	1250
Diameter of pipes, inches	$\frac{1}{2}$	1	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
Price with brass case ...	£4 10	£5 10	£8 10	£9 10	£11 10	£12 10	£15	£17
" iron " ...	...	...	£6	£7	£8	£9	£10	£12

The cost of packing for shipment and delivery f.o.b. is usually about 5 per cent.

CENTRIFUGAL PUMPS.

The arrangements of Centrifugal Pumping Machinery are too diversified to admit of the subject being completely illustrated in the space available, but one or other of those now referred to fulfil most of the conditions usually met with, leaving other and exceptional arrangements for special consideration and design.

Height of lift.—The limit of height for which the centrifugal pump can be advantageously employed, depends upon constantly varying circumstances. In some cases it may be as much as 50 or 60 feet, whilst in others it should not exceed 20 to 25 feet from the level of the water at the suction end, to the point of discharge. See remarks on Centrifugal Pumps at page 2.

Efficiency.—A centrifugal pump working within the above-named limits (all items of cost being capitalised) will probably be almost, if not quite, as economical as a reciprocating pump.

Cost of installation.—The initial outlay, including machinery, foundations, buildings, etc., will be much less for centrifugal than for reciprocating pumps of equal capacity. The centrifugal pump being continuous in action causes less vibration than most other types, and for this reason (amongst others), is used with advantage in swampy or soft ground or where foundations are expensive.

Driving power.—For temporary use, no motor compares with the familiar portable steam engine, or a gas or oil engine. But for permanent use, where economy in consumption of fuel is sought, a compound condensing engine may be expected to give the best results. This subject is dealt with at pages 1 to 4 in Section I. of this series.

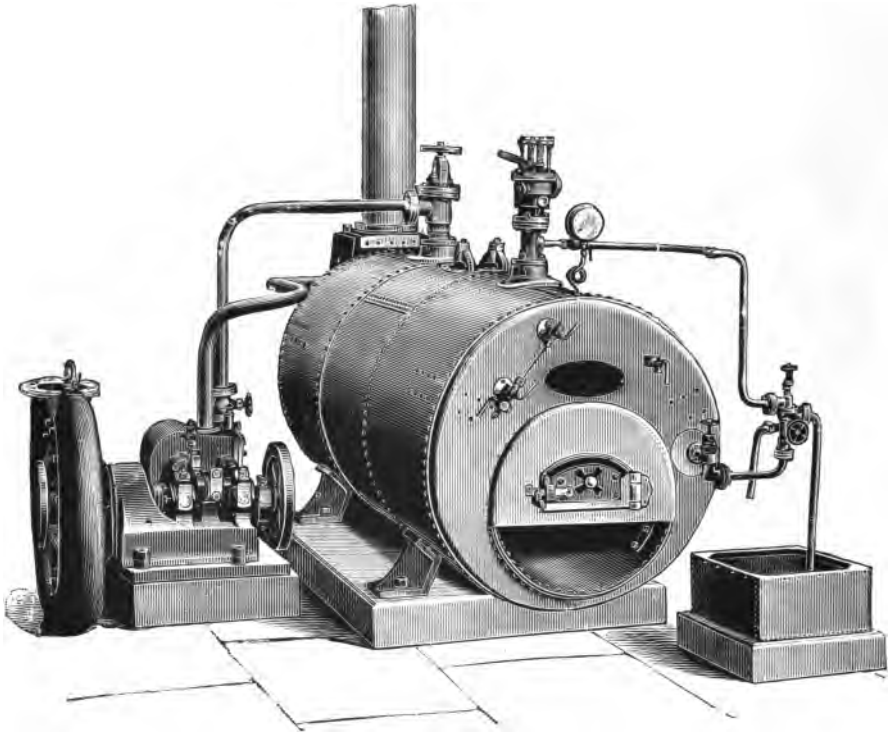


Fig. 2565.

DIRECT ACTING CENTRIFUGAL PUMPING PLANT.—Installations similar to that illustrated by Fig. 2565, with many modifications, have been successfully employed for drainage, irrigation and other purposes.

The pump and engine being on the same bed plate, may be fixed in any position relatively with the boiler and at any reasonable distance from it. The pump disc secured to one end of the crank shaft and the fly wheel at the other end, insure regularity in revolutions. The engine, with or without condenser, is designed and constructed in the manner required for running at high speed.

Priming.—If the pump is not in constant use, an exhaust apparatus should be provided, as shown in Fig. 2566, for charging. The prices will be found at page 78.

The boiler illustrated is semi-multitubular, but obviously one of the locomotive or other type may be substituted for that used in this instance, or steam may be supplied from an existing boiler.

Estimates of cost.—The dimensions of pump, height of lift, construction of engine and other details vary too widely to admit of the cost of installations of this kind being tabulated, but data for approximate estimate will be found by reference to the tables at page 78, which give the driving power required, the prices of pumps and accessories; those relating to engines, boilers and fittings are given in much detail in Section I.

DIRECT ACTING CENTRIFUGAL PUMPING ENGINES.—The combinations and dimensions of pumps, height of lift, positions of suction and delivery pipes, types and arrangement of engines, boiler pressures, and so forth are almost endless, and the engravings, Figs. 2565 to 2568, must be regarded merely as typical and capable of modification to suit widely varied conditions.

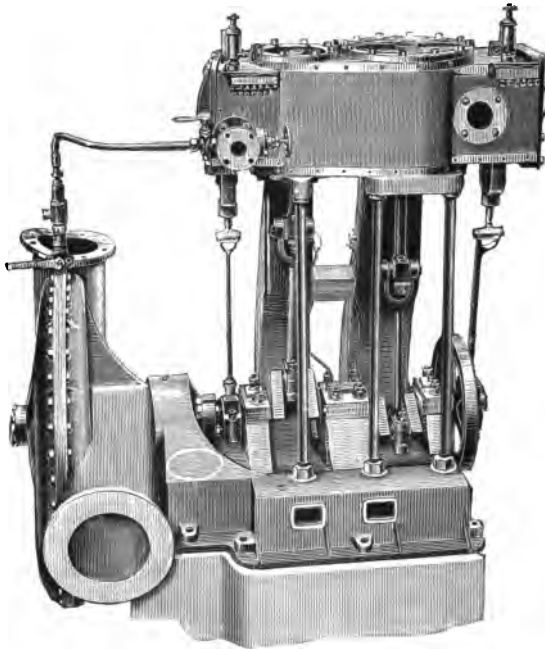


Fig. 2566

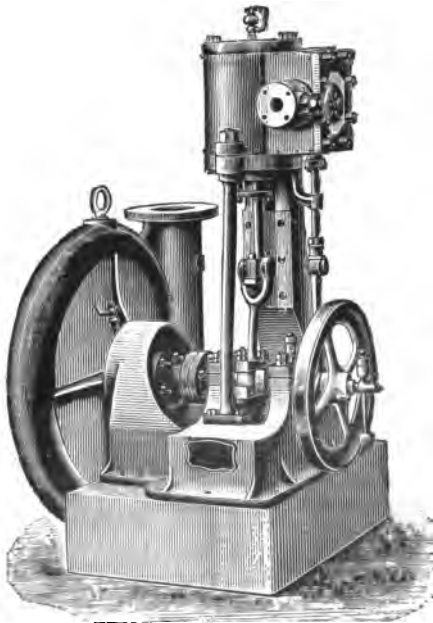


Fig. 2567.

The engines.—The crank shaft is coupled to the pump spindle and the engines are compound, as Fig. 2566 or single cylinder non-condensing as Figs. 2565 and 2567. A tandem engine is not illustrated, but all types are built with or without condens rs.

Pumps and engines in duplicate are fixed side by side, or otherwise, as may be convenient, but whatever may be the arrangement, the journals and wearing surfaces are ample and facilities are provided for lubrication and examination.

The pumps, driven by direct acting engines, have discs of large diameter, to obtain the peripheral velocity necessary for working economically with a moderate speed of piston. Provision is made for access to the disc without disturbing either the suction or delivery pipe and for leading them in any direction desired.

Position of pump.—See the paragraphs "Information required," "Duty," etc., at page 4.

Compound centrifugal pumping engines, Fig. 2566, are usually provided with surface or jet condensers but the price cannot conveniently be tabulated.

The approximate prices of single cylinder pumping engines, Fig. 2567, of usual dimensions are given at page 71.

Prices of pipes and accessories will be found at page 78.

PRICES OF SINGLE CYLINDER PUMPING ENGINES, Fig. 2567.

Diameter of pipes inches	3	4	5	6	7	8	9
Approx. capacity, gallons per minute...	150	250	400	550	800	1000	1300
Price of pump and engine	£75	£80	£85	£100	£110	£130	£140
„ for brass disc extra	£3	£4	£5	£6	£7	£8	£10
„ brass spindle „	£2 10	£3	£3 10	£4	£4 10	£5	£6

PRICES OF SINGLE CYLINDER PUMPING ENGINES (*Continued*).

Diameter of pipes inches	10	12	13	14	15	16	18
Approx. capacity, gallons per minute...	1650	2400	2800	3250	3750	4300	5400
Price of pump and engine	£150	£175	£200	£240	£270	£300	£325
„ for brass disc extra	£14	£15	£18	£20	£22	£25	£35
„ brass spindle „	£6 10	£7	£7 10	£8	£9	£10	£12

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

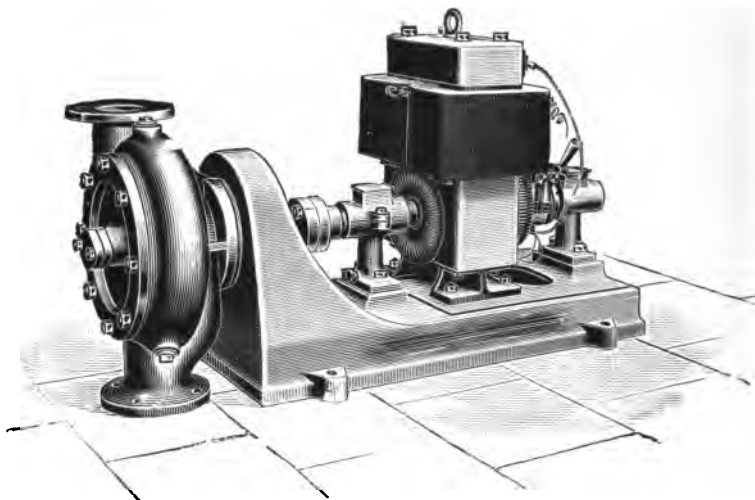


Fig. 2568.

CENTRIFUGAL PUMP DRIVEN BY ELECTRIC MOTOR. Attention has been directed elsewhere to the facilities afforded by the use of the electric motor in connection with pumps, and Fig. 2568 indicates a combination adopted with marked economy and advantage under many circumstances where a steam or belt driven pump would be inadmissible.

The small space occupied by these pumps, relatively with their output, the absence of vibration and the certainty with which any number of pumps are controlled from a central station, recommend them for use under conditions for which it would be difficult to employ any other type of pump.

An example of this is found in an installation for raising sewage at points widely separated, but where all the pumps must be controlled by the engineer in charge of the dynamo house. After careful consideration of every known system, it was found that electrically driven centrifugal pumps would be the most economical and convenient solution of a problem which, although by no means uncommon, is rarely easy to deal with satisfactorily.

The prices of these pumps cannot be accurately defined until data of the nature indicated at page 4, has been supplied. See "Information required."

The important points are the pressure of current (if any) available and the height to which a given quantity must be raised in a given time. Divergences in these conditions naturally affect the cost of the installation, but it will probably not differ widely from one of equal capacity with direct acting engine, as illustrated by Fig. 2567.

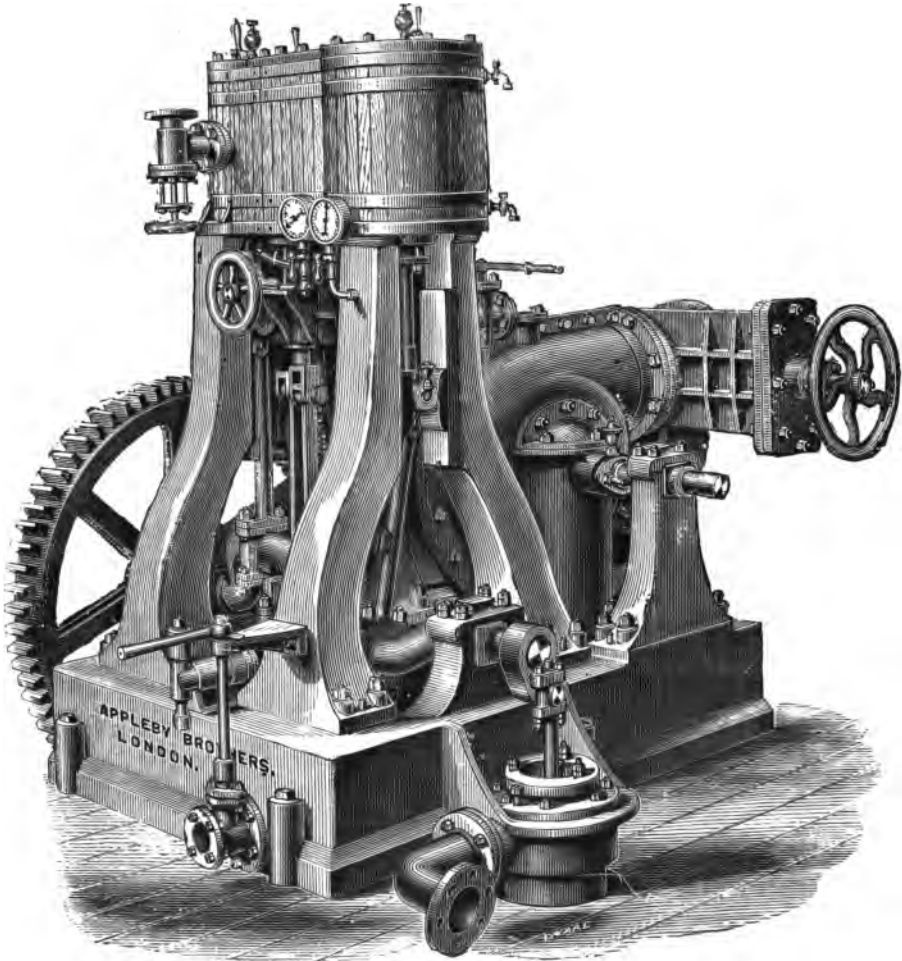


Fig. 2569.

COMPOUND CONDENSING ENGINE AND GEAR DRIVEN CENTRIFUGAL PUMP.—Fig. 2569 represents an installation for irrigation (in Egypt) which delivers about 2500 gallons of water per minute to a height of 20 feet. The same type is made with single and double cylinders and non-condensing.

The compound engine is carried on a heavy bed plate deep enough to form the jet condensing chamber, the connection and regulating cock for which are shown in the engraving. The ram and the bucket air pump is driven from a crank arm on the end of the crank shaft, and the injection water is taken from an existing reservoir.

The centrifugal pump is fixed on a continuation of the engine base plate, and is fitted with covers for examining the disc without disturbing bearings, etc. The outlet is provided with a sluice valve. The fly spur wheel on the crank shaft gears with a pinion on the pump spindle, which makes three revolutions for each double stroke of the engines.

The boiler is of the locomotive type, with large fire box and straw burning apparatus as shown in Fig. 2572, and is complete with all furnace, steam and feed water fittings, including an injector; there is also a feed pump on the engine, driven from one of the valve eccentrics in the usual manner.

The prices of boilers and accessories will be found on pages 24 to 68 of Section I. If steam is to be taken from an existing boiler, the pressure available should be stated.

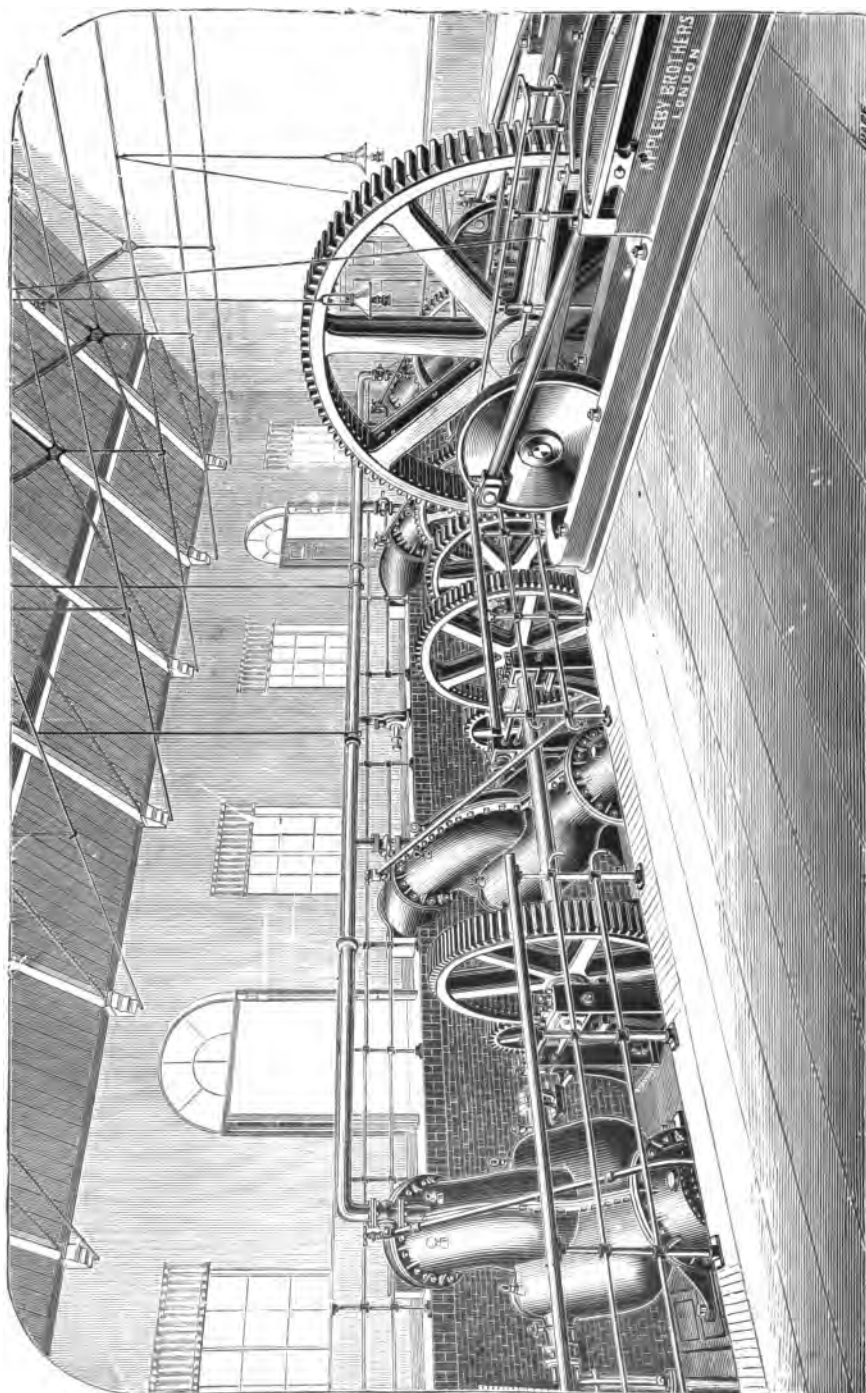


Fig. 2570.

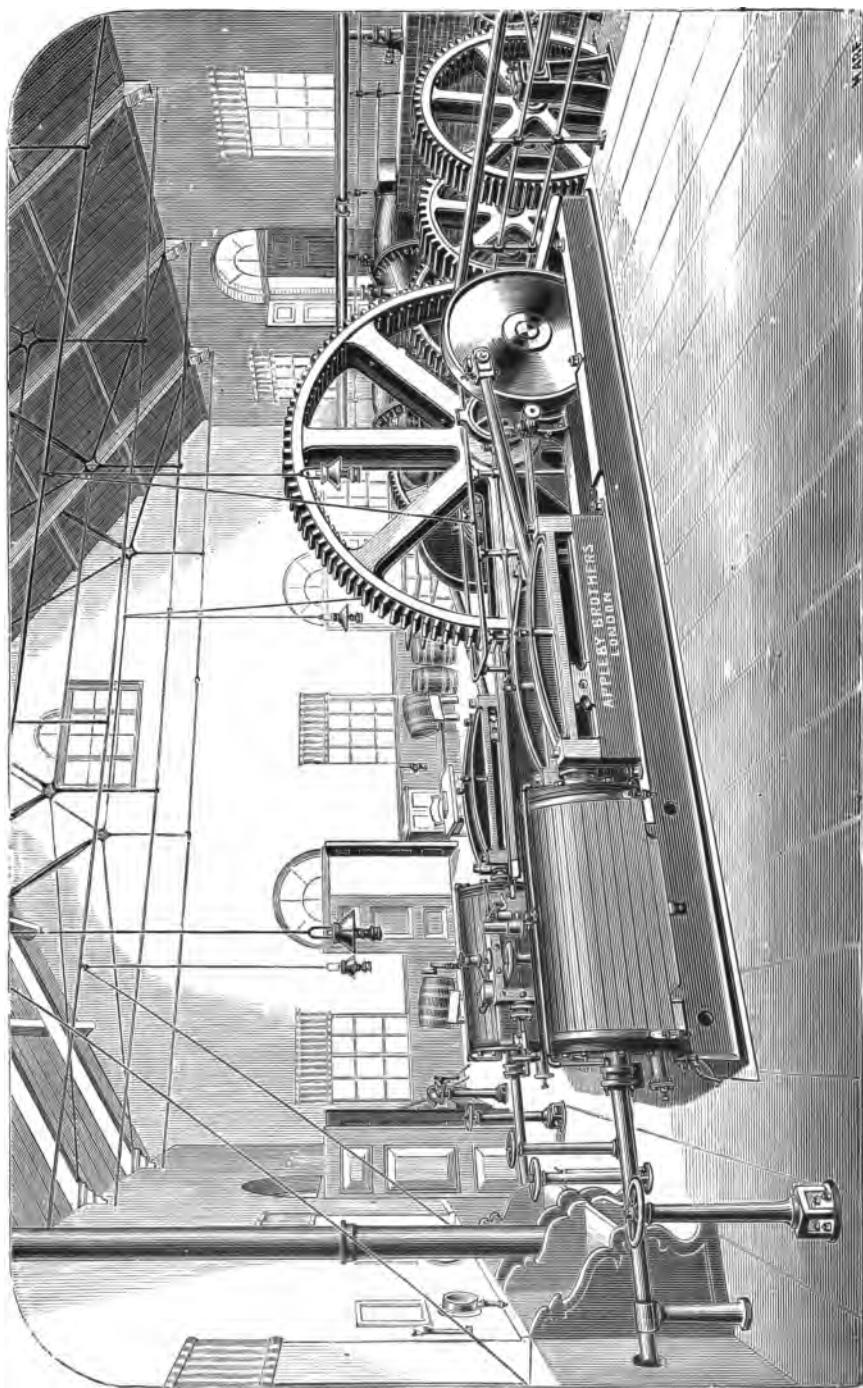


Fig. 2571.

CENTRIFUGAL PUMPS FOR DRAINAGE OR IRRIGATION.—

Figs. 2570 and 2571 represent an installation designed and built by the writer's firm for draining a large tract of "Polder" land; a similar arrangement of plant is obviously suitable for irrigation.

The four centrifugal pumps have suction and delivery pipes, 30 inches diameter, and each pump is capable of raising 90,000 tons of water per 24 hours to a height of 16 feet 4 inches (5 metres). Provision is made for working the pumps simultaneously or in any combination.

The engines are fitted with expansion gear which, as the level of water recedes, can be regulated to the highest grade of expansion at which the work can be performed.

Arrangement of machinery.—A pair of horizontal and surface condensing engines, with adjustable expansion gear, are fixed centrally and transmit motion to the countershaft, from which the pumps are driven; two pumps are on each side of the engines, and all wheels and pinions are carried between bearings, as shown in the engravings.

The circulating water for the surface condenser (not shown in the engravings) is supplied by a centrifugal pump, and this, as well as the air pump, is driven by a small horizontal engine similar in construction to those illustrated.

Steam is supplied from four Cornish boilers, with water heating apparatus, and the usual donkey feed pump, fittings and accessories and valves are provided for working the engines without condensation, in case of need.

The price of a pumping plant, similar to that now referred to, including all pipes, connections, etc. is about £5500

The machinery illustrated has been highly successful, but the more modern practice is to put down separate compound engines and pumps, or an extension of the crank shaft, as indicated in Fig. 2566.

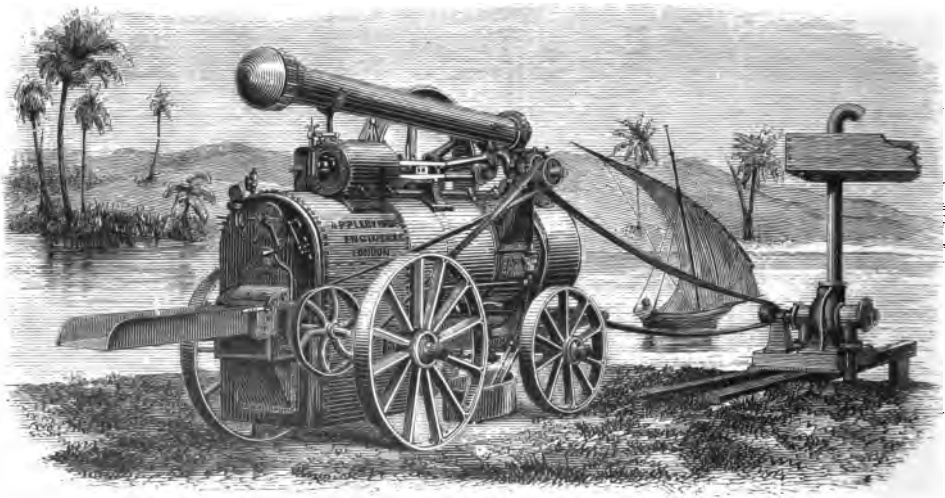


Fig. 2572.

PORTABLE ENGINES AND CENTRIFUGAL PUMPS arranged as shown in Fig. 2572 are so largely used in connection with drainage, irrigation, sheep washing and many other industrial and agricultural operations, that detailed description of the machinery will be unnecessary.

The pump is of the type illustrated by Fig. 2574, and is provided with facilities for examining and clearing the disc of weeds, refuse or other obstructions.

The engine has an extra large fire box fitted with apparatus for burning straw, cotton stalks or other agricultural refuse, as required in Egypt, the colonies and elsewhere. The travelling wheels are made entirely of iron and are unaffected by dry heat or the attack of insects. Engines of this and other types are fully described at pages 10 to 40 of Section 1 of this series.

The prices of engines and pumps are based on a height of lift of 15 feet from water level to delivery and do not include straw burning apparatus. For pipes, etc. see page 78.

Duty.—By driving at a higher speed than is contemplated in the subjoined table, the quantity of water delivered is increased up to 40 to 50 per cent. but with some loss in useful effect.

PRICES OF PORTABLE ENGINES AND CENTRIFUGAL PUMPS, Fig. 2572.

Diameter of pipes inches	6	8	10	12	14	16
Approx. capacity, gallons per minute ...	500	1000	1500	2250	2800	3500
Price of engine and pump	£159	£178	£264	£328	£451	£580
„ pump only	£22	£30	£42	£73	£86	£100
„ 50 feet of leather belts	£7 10	£11 5	£12 5	£17 10	£26	£31 10

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

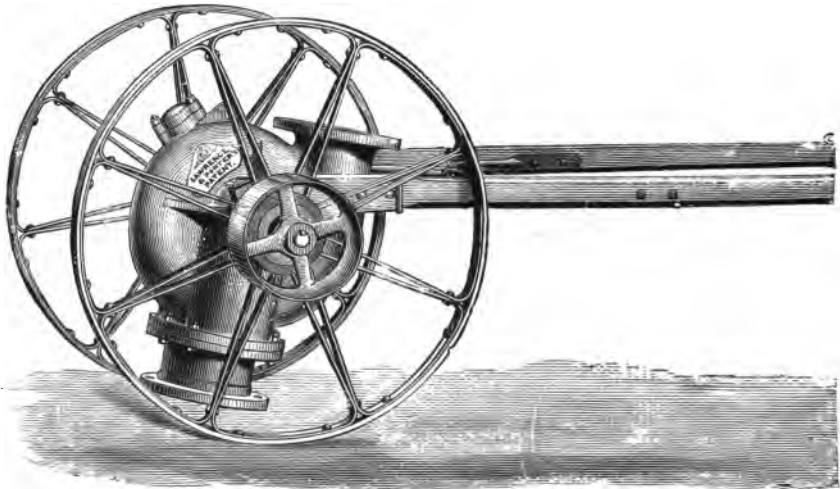


Fig. 2573.

PORTABLE CENTRIFUGAL PUMPS, of the construction illustrated by Fig. 2573, are easily moved and fixed for irrigation or drainage.

The pump is carried between a pair of wrought iron wheels with shafts, or with a pole for hauling by bullocks, or by a traction engine. The angle of the pump is adjustable, and the shafts (or pole), coupled to the fore part of a portable engine, maintains alignment for driving by belt from the fly-wheel, as indicated in Fig. 2572.

The prices of pipes and accessories will be found at page 78. The subjoined prices include shafts or pole and a driving pulley of the diameter usually required.

PRICES OF PORTABLE CENTRIFUGAL PUMPS, Fig. 2573.

Diameter of pipes inches	4	5	6	7	8	10	12
Approx. capacity, gallons per minute...	200	350	500	750	1000	1500	2250
Price of pump, with shafts, etc. ...	£22	£28	£32	£40	£47	£65	£80

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

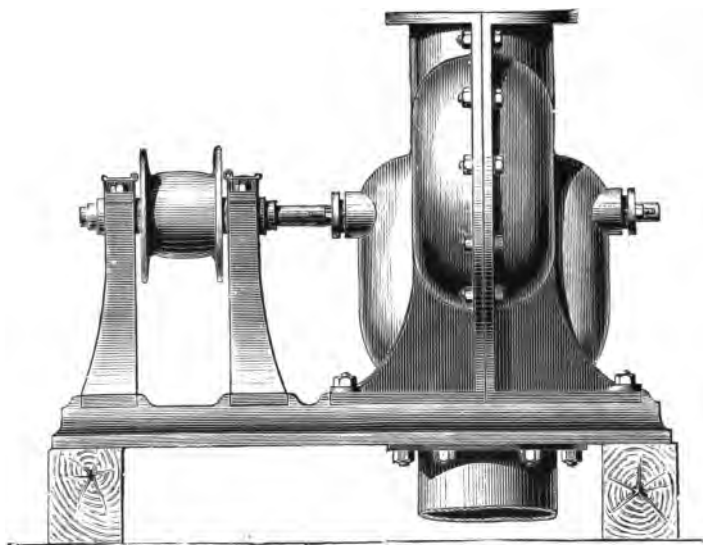


Fig. 2574.

CENTRIFUGAL PUMPS DRIVEN BY BELT.—Fig. 2574 represents a pump with two standards and bearings to carry the pulley end of the spindle, as required for high duty in quantity or height of lift.

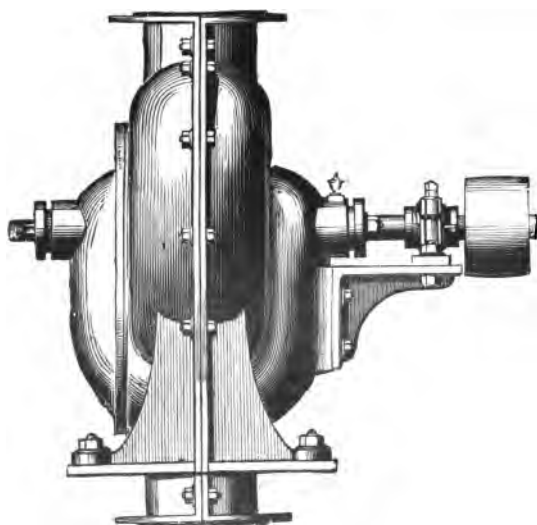


Fig. 2575.

The pump, Fig. 2575, with pulleys outside the bearing is the type used for moderate lifts.

The suction and delivery pipes are arranged to lead in the direction desired, and provision is made for examining the disc without disturbing the pipes.

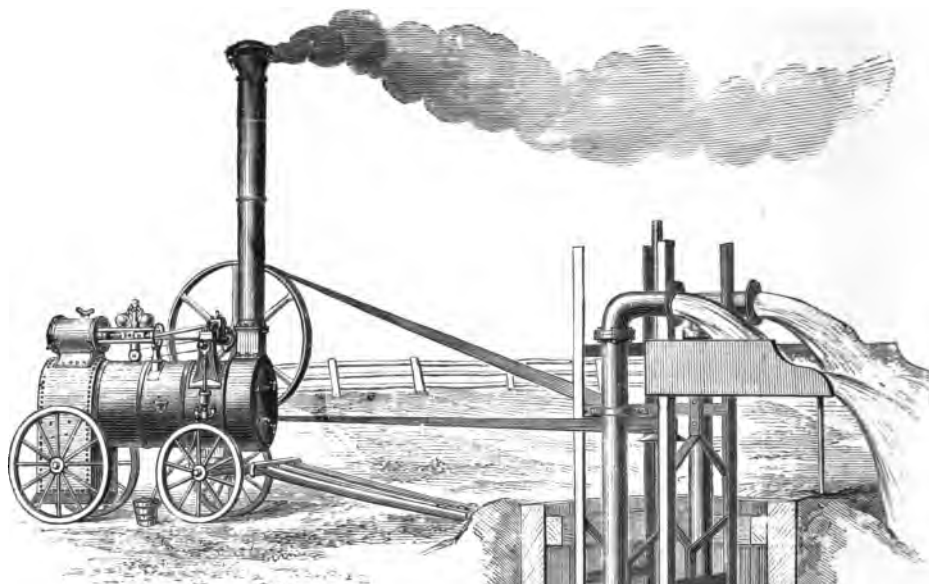
Pulleys and shafts.—The pulleys are made with or without flanges, as circumstances require; the shafts are of mild steel, and the bearings are fitted with lubricators.

Efficiency.—The quantity delivered by the respective sizes mentioned may be regarded as normal when working at a moderate speed, but the output is greatly increased by running the pump at higher speed. The loss in useful effect (referred to elsewhere) is of little importance when the work is only temporary.

Delivery pipes.—If these are of great length, friction is much reduced if the pipes are larger in diameter than the pump outlet, the connection being made by a taper piece.

Position of pump.—See the paragraph "Information required," "Duty," etc. at pages 2 to 4.

The engine power required for any given height of lift is easily ascertained, but the following approximate data relating to the **nominal** H.P. requisite for 25 feet lift and a moderate length of delivery pipe, will be useful for making approximate estimates.



WOODFORD CENTRIFUGAL PUMPS are adapted for use when the pump can be submerged as shown in Fig. 2576. The pump disc revolves horizontally, but the principles of construction do not differ materially from those previously referred to.

The frame is of wrought iron or mild steel with corner angles and lattice bracing and carries the driving shaft, pump and rising mains. The frame is lowered into the caisson, well, or sump and is easily increased in length if the pump has to be lowered.

The vertical driving shaft is supported by gun-metal bearings at top and bottom and at suitable intervals. A pulley at the upper end driven by a half-twist belt is usually the most convenient mode of working and is quite satisfactory.

The pump is fixed horizontally at the bottom of the frame. The suction is central and is surrounded by a strainer, as shown in the engraving, which prevents large stones or too much solid matter being drawn into the pump.

Engines, electric and other motors are referred to in detail in Section I., but for convenience in making approximate estimates, the cost of portable steam engines is given, together with the prices of driving belts.

As the power must be increased with the height of lift it follows that, if 4-horse power is required for a pump which raises 1000 gallons per minute to a height of 10 feet, 6-horse power must be provided to lift the same quantity to a height of 15 feet, and so on.

If the height of lift exceeds 25 to 30 feet, or the pumps are of larger capacity than those given in the accompanying table, the vertical shaft is usually coupled to a pair of specially designed engines.

Fig. 2576.

PRICES OF WOODFORD CENTRIFUGAL PUMPS, Fig. 2576.

Diameter of pipes (two) inches	3½	4½	5½	6	8
Approximate capacity, gallons per minute	500	1000	1500	2000	3000
Price complete for depth of 10 feet	£35	£44	£52	£69	£100
„ „ per foot extra height	20/-	24/-	27/-	30/-	36/-
Nominal horse power required for 10 feet lift	2½	4	6	8	12
Price of portable steam engine	£130	£150	£180	£210	£280
„ „ leather driving belt per foot	2/11	4/6	4/10	7/2	8/11

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

CENTRIFUGAL PUMPS WITH THREE CYLINDER ENGINES.—

The cross section of the Floating Dock for which this machinery was made is similar to that indicated in Fig. 2577, but it was built in three sections, each about 50 feet long, 56 feet wide, and 20 feet deep, for use separately or in combination as required.



Fig. 2580.

Each section is provided with its own pumping plant, steam being supplied from a boiler on a barge alongside, with flexible hose connections and suitable couplings to the steam pipes on the dock.

The pumps are of the type Fig. 2579, and are fixed at the bottom of the dock. Each pump delivers 10,000 cubic feet of water per hour at a height of 20 feet when working at about 350 revolutions per minute, but provision is made for discharging at a lower level when the dock rises. The suction and delivery pipes are 9 inches internal diameter and valves at the bottom, which are worked from the deck, admit of the dock being pumped quite clear. The disc and spindle are of gun-metal, and the thrust bearing in the bridge piece is lined with lignum vitæ.

The engines, of the three cylinder single acting type, are carried on a base which is fixed as shown below the deck, and are connected with the pump by a mild steel shaft carried in pedestals with lignum vitæ bearings. The piston rings, glands, connecting and valve rods are of Delta metal and balanced for high speed working. The Boiler is of the locomotive type, and is constructed for a working pressure of 100 lbs. per square inch.

The cost of the plant, consisting of three engines, each with centrifugal pump, driving shaft and bearings, suction and delivery pipes, valves, locomotive boiler, etc. as above described is about £740

CENTRIFUGAL PUMPS FOR FLOATING DOCKS will be referred to in Section V. but it may be briefly mentioned here in connection with machinery which has been successfully employed.

Arrangement of machinery.—The diagram, Fig. 2577, shows a cross section of the dock, and indicates the position of the pumping plant. The inlet valves at the bottom being opened, the dock is water ballasted until it will float under the keel of the vessel to be docked. There are two inlet valves to each group of three pumps, and the admission of water ballast is controlled by spindles which pass up the side of the dock and are manipulated from the engine platform. By this means any, or all of the compartments can be ballasted and float rods, indicating the depth of water, admit of the dock being adjusted to the position desired.

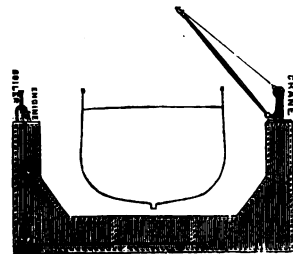


Fig. 2577.

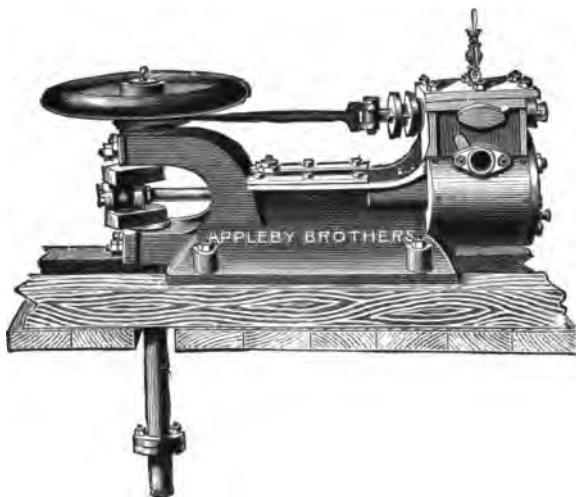


Fig. 2578

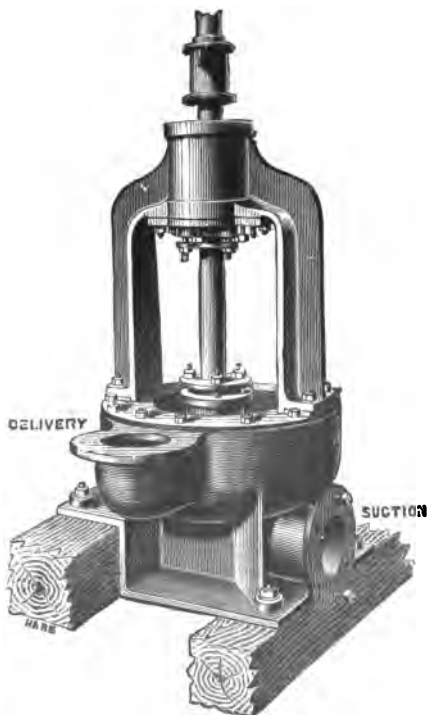


Fig. 2579.

The dock is then floated into position, the vessel shored and the pumps set to work to empty the compartments and so raise the vessel clear of the water.

The centrifugal pumps, whatever may be the size, are usually of the type, Fig. 2579.

The engraving represents a pump with suction and delivery pipes of 8 inches diameter; the pump discs and spindles are of gun-metal and the latter are carried up the side of the dock to the engine platform.

The weight of the disc and spindle is carried by a thrust bearing in the bridge piece above the pump case; the wearing surfaces are gun-metal and hard wood (*lignum vitæ*), which work perfectly well under water without lubrication.

The suction pipes are each provided with a sluice valve, the ends are bell mouthed and turned down into a metallic sumph let into the bottom of the dock, so that it may be perfectly drained by the pump, for examination.

The engine, Fig. 2578, is of the horizontal high speed type. The crank shaft, piston and piston rods are of steel, the cross-head and guide block are in phosphor bronze, the bearings have large wearing surfaces and the fly wheel is turned and balanced.

The cost of a plant consisting of nine engines and centrifugal pumps, six gun-metal inlet valves with spindles, hand wheels and accessories, thirty sluice valves, spindles, etc., a locomotive boiler of about 75 effective horsepower, with fittings and all steam and other pipes and connections, is about ... £2250

The cranes on the side of the docks are valuable under many conditions. Illustrations and descriptions of most kinds in general use will be found on reference to Section II. of this series.

Steam cranes, which take their supply of steam from the main boiler, are frequently preferable to hand-worked cranes.

CENTRIFUGAL PUMPS AND ENGINES COMBINED, of the type Figs. 2566 and 2567, fixed in water-tight walls, are sometimes preferred to those now referred to, all being supplied with steam from one boiler.

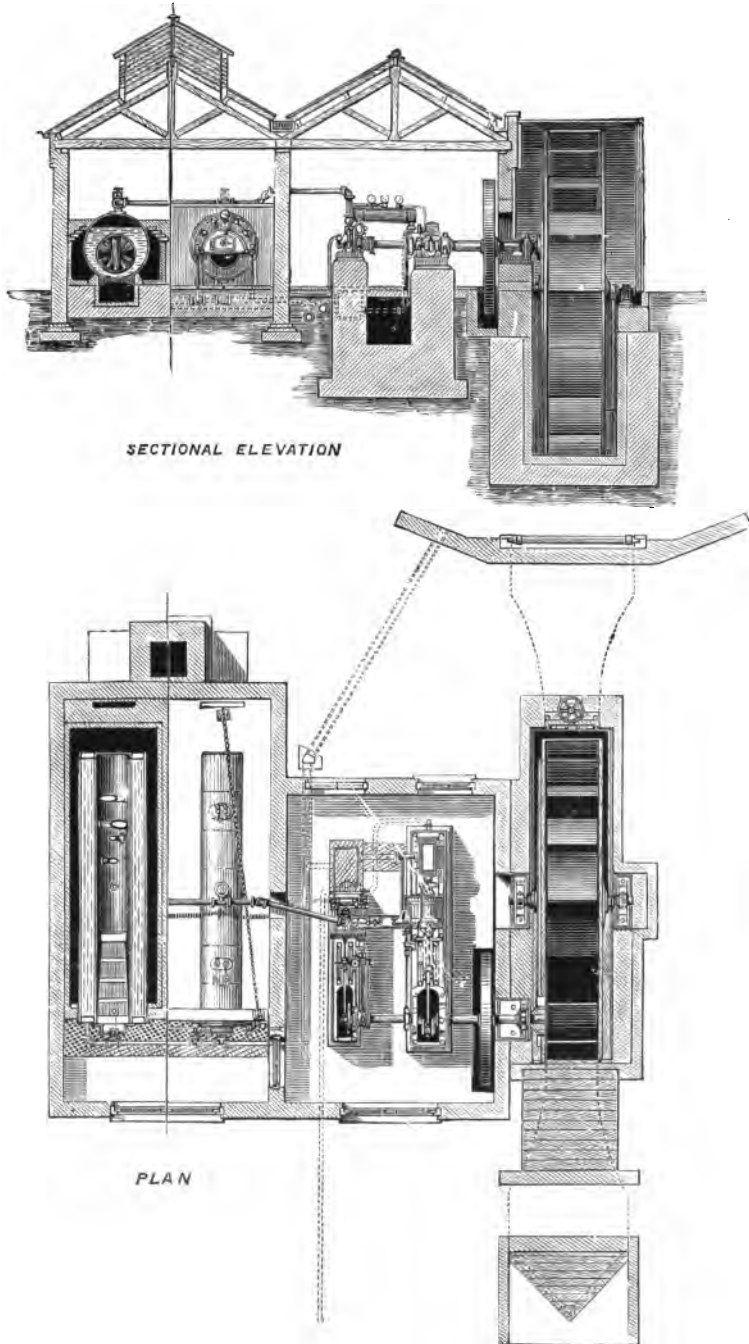


Fig. 2581.

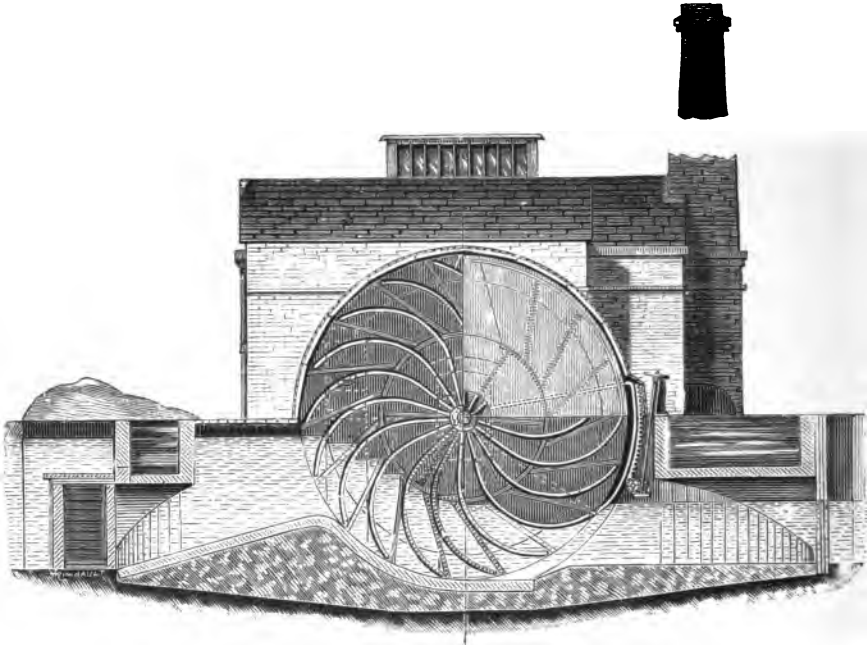


Fig. 2582.

SCOOP WHEELS.—Although the more compact and less costly centrifugal pump has largely superseded machinery of this kind for raising large quantities of water charged with vegetable and other matter, a well designed scoop wheel working on a lift not exceeding 4 or 5 feet, compares favourably in cost of working and maintenance with the more modern appliances.

The machinery illustrated by the diagrams Figs. 2581 and 2582, has worked for many years on a very low consumption of fuel and an almost total absence of repair.

The **scoop wheel** is built of wrought iron and is capable of delivering 3500 cubic feet (about 22,000 gallons) of water per minute to a height of 4 feet or a proportionately smaller quantity to a greater height.

The diameter of the wheel is 24 feet, the width is 4 feet and the blades are curved as shown in Fig. 2582 to enter the water easily and free themselves rapidly; they are shrouded by wrought iron plates on each side which are carried into the centre. The wheel is carried on a wrought iron shaft with heavy pedestals and gun-metal bearings and is driven by a spur ring on the inner side which gears with a steel pinion on the engine shaft.

The sectional areas of the inlet and delivery culverts are proportioned to give a speed of flow corresponding, as nearly as possible, with the speed at which the blades travel.

The **engines** are compound with jet condenser behind the low pressure cylinder; the high pressure cylinder is steam jacketed and fitted with Meyer's expansion gear which is adjusted, whilst the engine is running, to bring the consumption of steam into exact relation with the duty in water lifted.

The **boilers** are of Cornish type (Fig. 1522, Section 1) with Galloway tubes in the internal flues, and are complete with all fittings, steam pipes and accessories. The working pressure is 8c lbs. per square inch, and one boiler suffices excepting in flood times.

The **cost of this machinery** is about £1850

The **cost of building**, including foundations, engine and boiler house, brick chimney about 60 feet high, store for about 60 tons of coal, casing for the scoop wheel, etc. was about £700

But this item is so much affected by the nature of foundations, cost of materials, labour and other local conditions, that all these need to be carefully considered for each installation.

Foundations for pumping stations.—Errors in judgment on this important subject lead to so much trouble and expense, that it is difficult to overestimate the importance of the machinery and foundations being suitable for the strata on which they must be erected.

Many instances could be mentioned where large sums of money have been wasted, simply by attempting to use machinery which would be highly economical if the strains could be distributed over a sufficient area, but which fails to be by the reason of the excessive cost of maintenance due to insufficient foundations. Such results can almost always be avoided when the local conditions have been studied with a view to the proper distribution of strains.

PULSOMETERS raise water and many other fluids (or semi-liquids) to any height up to 80 feet or more, and under widely differing conditions, some of which are illustrated by

Figs. 2585 to 2588, and mentioned in the following descriptions :—

The action of the pulsometer will be understood by reference to the sectional diagram, Fig. 2583, which shows that the pumping action is due to the vacuum created alternately in the chambers AA by the steam being rapidly condensed when brought into contact with water.

To obtain this result steam conveyed by the pipe K and admitted by the ball valve I—forces the water accumulated in one of the chambers A through the discharge chamber F.

The vacuum created by condensation draws over the ball valve I, and opens the admission of steam to the other chamber which has been filled by the ingress through the valve E. The direction of the arrows shows how the cycle of operations is repeated.

The suction valves E are of the grid, flap, ball, or other type, as required for the liquid to be raised; but the grid valve is the best for most liquors, and for that reason is selected for illustration.

The pressure of steam at the pump should not be less than 20 to 30 lbs. per square inch for lifts up to 20 to 40 feet.

For lifts between 40 to 80 feet vertically, the steam pressure required is 35 to 50 lbs. per square inch.

An automatic expansion valve, represented by Fig. 2584, can be fixed to Pulsometers of not less than 10,000 gallons capacity, above the ball valve I, Fig. 2583. This valve effects a saving of 40 to 50 per cent. in the consumption of fuel, which amply repays its extra cost if the pulsometer is at all continuously employed.

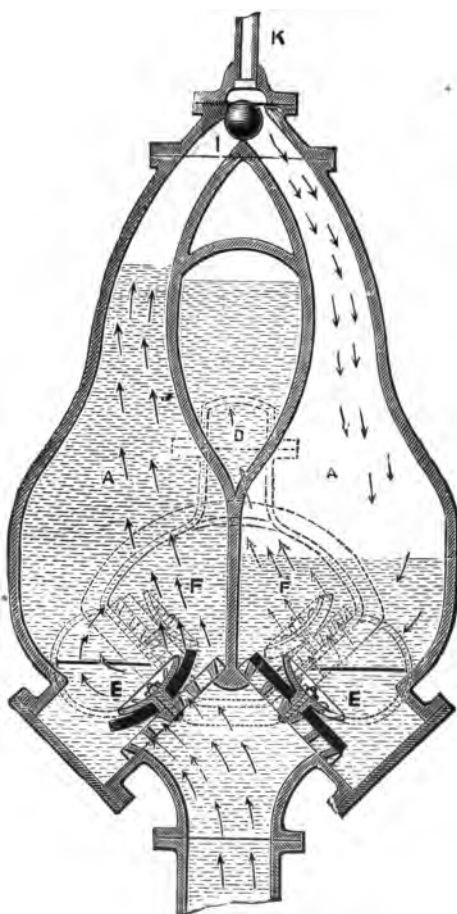


Fig. 2583.

The above-named economy closely resembles that obtained by the use of automatic cut-off valves in connection with steam engines, to which reference is made at page 3 (and elsewhere) in Section I of this series.

Position of pulsometer.—It should be as near to water level as convenient, and the suction should, in no case, exceed 10 to 15 feet vertically. The length of horizontal pipe is not very material provided that the diameter is ample, and the joints are perfectly tight.

Capacities and tests.—The capacity is based on delivery to a total height of 20 feet, and the proper allowance must be made if that height of delivery is exceeded ; but all pulsometers are tested to a head of 80 feet, and the duty performed is carefully noted.

Spare parts, consisting of neck piece and ball, rubber valves, air valves, and rubber fittings for foot valves, suffice to maintain the pumping efficiency for a long time.



Fig. 2584.

Information required.—If advice is desired as to the appliances to be supplied, the under-named details should be given :

The quantity, nature and temperature of liquid to be raised per hour.

The heights of suction and delivery.

If steam is supplied from an existing boiler, the pressure at I Fig. 2583 should be stated.

PRICES OF PULSOMETERS AND ACCESSORIES.

Capacity, gallons per hour ...	3800	6000	10000	13000	17000	28000	40000	52000
Diameter of steam pipe inches	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	2
„ suction „ „	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	6	7	8
„ delivery „ „	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	5	6	7
Price of pulsometer, Fig. 2583	£18	£24	£32	£42	£55	£80	£100	£130
„ expansion valve, Fig. 2584	...	...	£8 15	£10 10	£12 5	£14	£15 15	£17 10
„ foot valve ...	£2	£2 15	£3 5	£4	£4 10	£6	£9	£10
„ spare parts ...	£2 15	£4	£4 15	£5 10	£6 5	£9 15	£12 5	£16 10
Approx. measurement, cubic feet	$8\frac{1}{2}$	10	15	20	30	50	70	105

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

Prices of pipes and fittings, flexible steam hose, etc., will be found further on.

PULSOMETERS FOR PUMPING CHEMICAL LIQUORS, or those carrying a large quantity (15 to 40 per cent.) of foreign matter, the valves and—for some purposes—the cases are made of materials which will not be affected by the liquid to be raised. If full details—such as those mentioned under the heading of “Information required”—are given, there is usually little difficulty in designing the appliances and estimating their cost.

PULSOMETERS FOR DRAINING TRENCHES, QUARRIES, MINES, etc. may be suspended from the timbering, as shown in Fig. 2585, or from a crane in the manner indicated in Fig. 2555, or in any way convenient for lowering to follow the depth of excavation. The pulsometer works automatically and continuously without attention, and can be instantly re-started after it has been idle for an indefinite period.

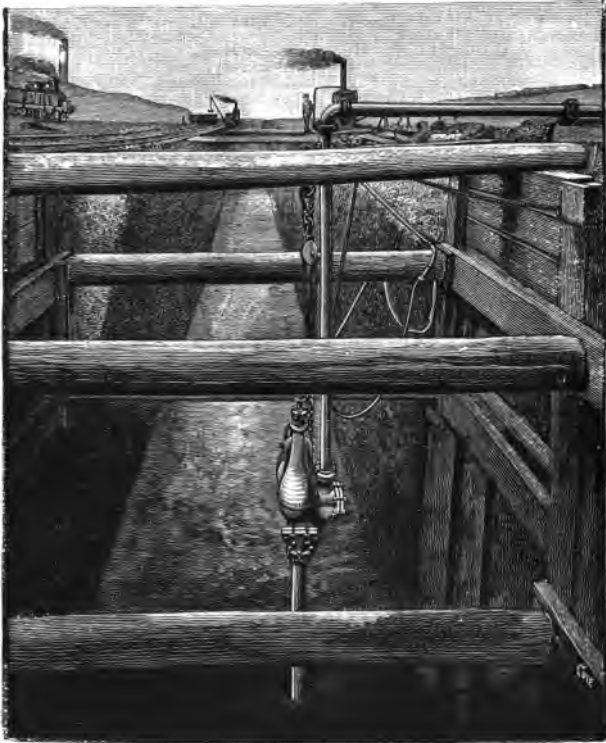


Fig. 2585.

For supplying locomotives or for similar service the pulsometer may be used in the manner last referred to, or it may be fixed alongside the source of supply, steam being taken from an existing boiler or from one provided for that purpose.

For pumping out ships' tanks or leakage in graving docks, the pump is usually fixed in the position most convenient for attachment of the suction connections to the tanks or parts to be drained, the delivery pipes being carried in the direction desired for discharge.

For distributing liquors in chemical works, tanneries, etc. the pulsometer may be suspended from a light overhead crane or from a jenny which travels on a rail or girder supported on brackets arranged to command the work to be performed.

For irrigation, domestic water supply, and many other purposes, the pulsometer is fixed at, or near, water level as shown in Figs. 2587 and 2588, the delivery pipe being carried to the point which presents the best facilities for distribution.

Pulsometer with portable boiler.—A pulsometer suitable for a total lift of 40 feet vertically is fixed on a bracket attached to the boiler; it is, however, easily removed for use in the manner shown in Fig. 2585 or suspended from a crane jib.

The boiler is of the vertical type (see Fig. 2587) with cross tubes in the fire box, and is complete with chimney and all usual furnace, steam, and feed water fittings—including an injector or a feed pump. The steam connections between the boiler and pulsometers (not included in the price) are wrought iron pipe or flexible hose, as convenient.

A boiler of the locomotive type is generally used for the steam supply to the larger sizes of pulsometers.



Fig. 2587.



Fig. 2588.

PRICE OF PULSOMETER WITH VERTICAL BOILER.

Capacity, gallons per hour	900	2000	3800	6000	10000
Price of pulsometer only	£8	£12	£18	£24	£32
„ „ and boiler on wheels	£46	£69	£85	£112	£140
„ „ „ without wheels	£40	£60	£75	£95	£115
„ water and steam pipe for 40 ft. lift	£2	£3 5	£5 5	£7 5	£9

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

Water pipes, bends, etc. for Pulsometers.—The following prices for stock sizes are given for convenience in estimating the approximate total cost of the plant.

The cast iron pipes have faced flanges and are made in lengths to suit the purpose for which they are required; lengths of 6 feet and 9 feet are usually ready for immediate delivery.

Wrought iron pipes have flanged joints faced and fitted and bolt holes drilled to template. These pipes are made in long lengths, so that there are comparatively few joints.

PRICES OF WATER PIPES FOR PULSOMETERS.

Diameter of pipe ... ..inches	2	2½	3	3½	4	5	6	7	8
Prices of C.I. pipes 6 feet long ...	6/-	7/-	8/-	9/6	12/6	16/-	20/-	27/6	30/-
„ „ 9 feet „	...	...	12/-	14/3	18/9	24/-	30/-	39/6	40/-
„ „ bends each ...	4/3	5/-	6/9	7/3	8/-	10/3	15/-	27/-	30/-
„ Wrought Iron pipes per ft.	1/3	1/6	1/9	2/-	2/6	3/6	4/8	7/9	11/-
„ flanges each	2/-	3/-	4/-	5/-	6/-	8/-	10/-	12/-	15/-
„ malleable bends ...	5/6	6/6	8/9	9/9	12/3	14/6	23 9	43 9	55/-
„ bolts, packing, etc. per joint	1/2	1/4	1/10	2/2	2/4	2/10	3/8	5/3	6/6

LIFTING TACKLE, FLEXIBLE STEAM PIPE, ETC.—As already indicated, the pulsometer may be suspended (or fixed otherwise) in any manner convenient, but—if it must follow the workings and a crane or suitable lifting tackle is not available the undernamed appliances should be provided:

A hand power winch, pulley block, chain sling and best tested crane chain for a total lift of 80 feet, also a length of flexible steam pipe to avoid the inconvenience of adding short lengths of steam pipe every time the pulsometer is lowered.

PRICES OF LIFTING TACKLE AND STEAM HOSE FOR PULSOMETERS.

Capacity of pulsometer, gallons per hour	10000	13000	17000	28000	40000	52000
Price of lifting tackle, per set	£10 15	£12 10	£15 10	£26	£30	£37
Diameter of flexible steam pipe, inches	½	¾	1	1½	2	2½
Price „ „ per foot	2/-	2/6	3/4	3/9	4/1	5/3
„ of set of 4 clips	7/6	10/-	15/-	18/-	20/-	30/-

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

BELT DRIVEN SEWAGE PUMPS.—Most of the pumps referred to in the preceding pages can be used for raising sewage or other foul liquids if they are fitted with valves which will not choke or be injured, even when pumping hard or gritty matter, but the pump now referred to (not illustrated) is specially designed for this duty.

A very successful arrangement for this purpose has been made in various sizes, up to about 55 inches internal diameter, and used permanently on sewage farms, and temporarily during the construction or alteration of sewers, the completion of main pumping stations, etc.

These pumps are driven by any of the ordinary types of engines illustrated and described in Section I.

The pump is of the bucket and plunger type, with special facilities for repacking the bucket and for examining the suction valves.

The suction valves are so constructed that neither the seatings or faces are injured by closing on hard substances, thus insuring a water tight joint and efficient action.

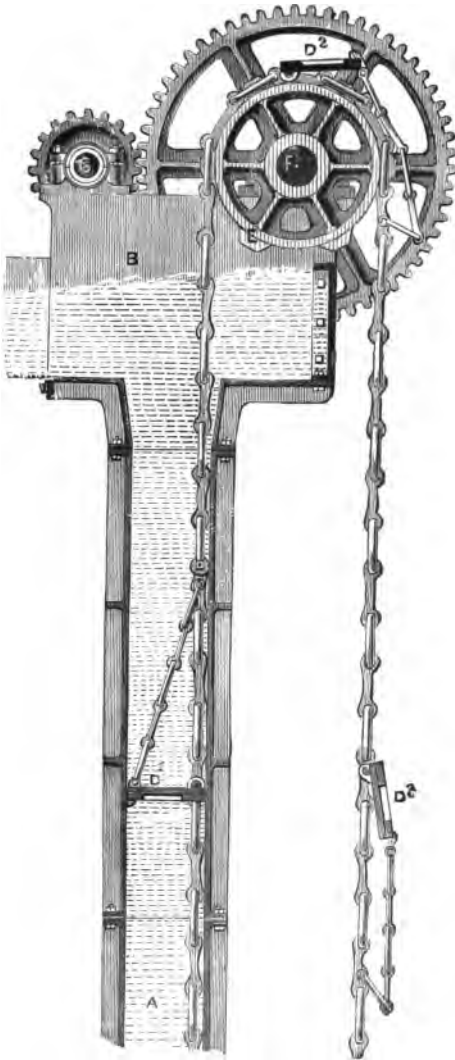


Fig. 2590.

Construction.—The barrel is rectangular and is formed of cast iron in lengths of 5 feet with flanges for bolting together, as shown in Fig. 2590. The lift **D1** works in the pump case **A**; the positions of the lifts, when the endless chain to which they are hinged has passed the discharge trough, are indicated by **D2** and **D3**.

If the pump is choked by any floating substance it is quickly cleared by reversing the traverse of the chain which causes the lift to fold, as seen in **D3**, and release the obstruction.

Closed back pumps, Fig. 2592, are constructed as above described, but the descending chain and lifts are enclosed in a wrought iron case, and are usually adopted if men must be below when the pump is at work.

Pumps of larger dimensions than those specified have double chains and geared heads; they are not tabulated, but range from 2000 to about 4000 gallons per minute capacity.

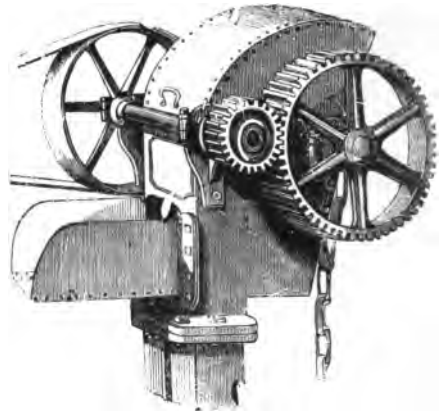


Fig. 2591.

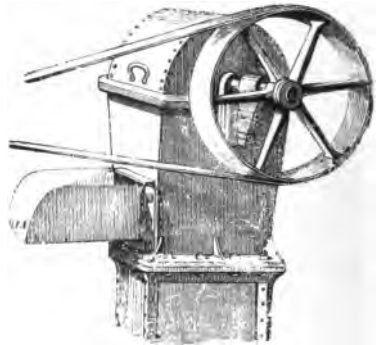


Fig. 2592.

MURRAY CHAIN PUMPS,

Figs. 2590 to 2592, are extremely simple in construction, and well adapted for draining sewers, coffer dams, sumphs, or where the water is highly charged with sand, gravel, mud, or other solids.

The chains and lifts are steered and it will be seen that there are no valves or packings liable to injury when pumping foul or gritty matter.

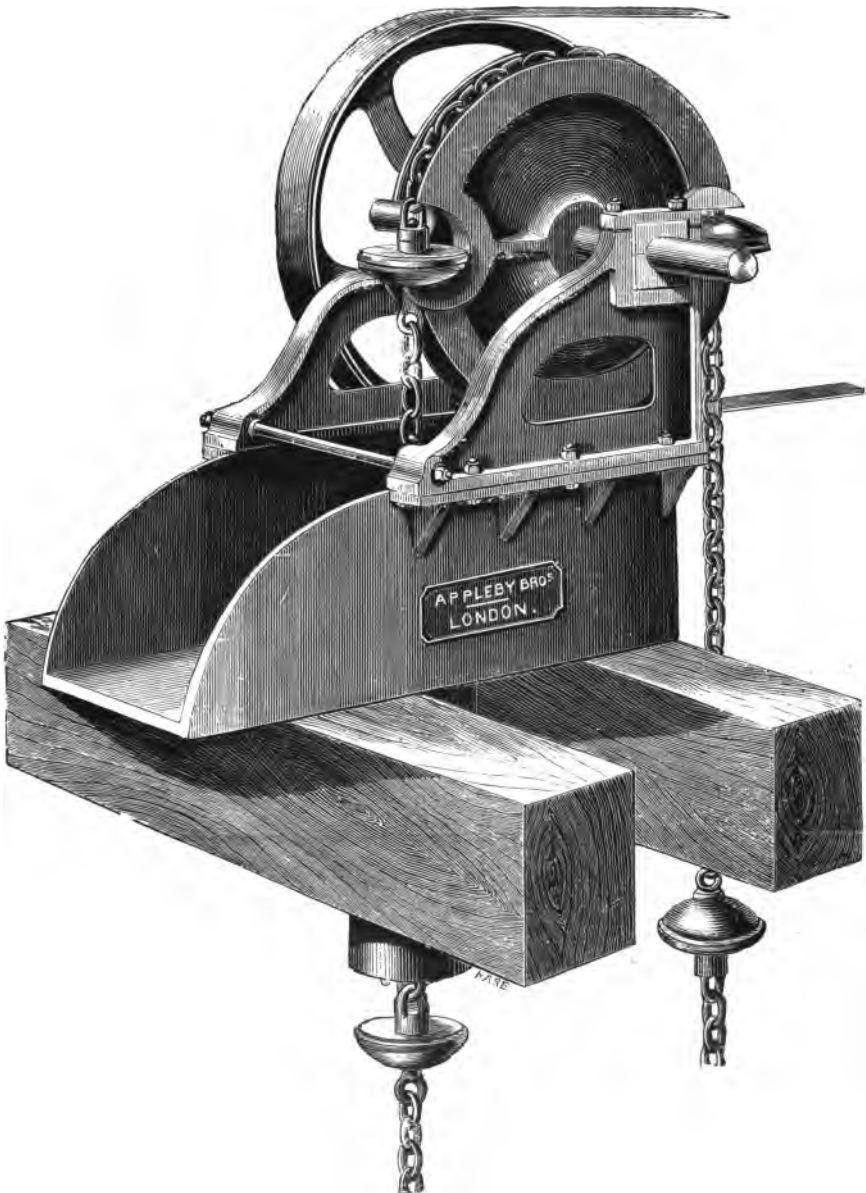


Fig. 2593.

The driving power is transmitted to the chain drum shaft by belt direct, as shown in Fig. 2592, or through intermediate gear as in Figs. 2590 and 2591. An extra charge is made for the intermediate gear if the pump is less than 40 feet high.

The cost of a pump of the capacity and height of lift required may be estimated by taking the price for the pump and for the extra height of lift, adding not less than two feet for the intake below, and the discharge trough, etc., at the top.

PRICES OF MURRAY SINGLE CHAIN PUMPS.

Dimensions of pump inches	8 × 4	10 × 5	12 × 6	14 × 7	16 × 8
Approximate capacity, gallons per minute	500	700	1000	1300	1600
Price of closed back pump for 10 feet lift	£40	£53	£65	£78	£90
" " each extra foot ...	£2 15	£3 8	£4 5	£4 17	£5 10
" open back pump for 10 feet lift	£36	£45	£55	£64	£72
" " each extra foot ...	£2 8	£3	£3 12	£4 2	£4 15

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

CHAIN AND DISC PUMPS of the construction Fig. 2593 are much used for raising water and other liquids and, as each disc becomes, in turn, a traversing retaining valve, the pump deals successfully with insoluble matter in suspension. The pump illustrated has been used for years in a cement works for pumping "slurry."

The pump head, to which the rising main is attached, is of cast iron and is fitted with gun-metal bearings which carry the chain drum and driving pulley or spur gear, as the case may be.

The rising main is made in lengths convenient for the work, the bottom being bell mouthed and is above this, slightly less in diameter than the upper lengths. This part of the pipe is bored to the diameter of the discs which are connected by the chain and retain the liquid until another disc has entered the barrel.

Pump head with intermediate gear.—This construction is adopted for high lifts or for working in connection with a high speed engine, or other motor; the cost is given below.

The subjoined prices include the head with discharge trough and driving gear, rising main, bell mouthed at the bottom and bored, as described, discs, chains, etc. for a lift of 10 feet, also the cost per foot of pipes, chains and discs for depths exceeding 10 feet.

PRICES OF CHAIN AND DISC PUMPS.

Diameter of barrel inches	3	4	5	6	7	8
Approximate capacity, gallons per hour ...	2500	5000	7500	11000	14000	18000
Price of pump for belt only	£17	£22	£24	£33	£36	£40
" " with intermediate gear ...	£20	£25	£28	£38	£42	£48
" for pipe, chain and discs, extra depth, per ft.	11/-	13/-	17/-	21/-	25/-	30/-

CHAIN AND DISC PUMP WITH ENGINE AND BOILER.—The engine is horizontal or vertical, and the pump gear is driven by a pinion on the end of the crank shaft as in Figs. 2516 and 2517, or by belt or rope as may be convenient.

The prices include the engine and boiler, pump head and driving gear, pipes, chain, discs, etc. for the depth mentioned. The cost per foot for extra height of lift is as above, unless increase in engine power is required.

PRICES OF CHAIN AND DISC PUMPS WITH STEAM POWER.

Diameter of barrel	3	4	5	6	7	8
Price of machinery for 10 feet lift	£76	£80	£85	£105	£112	£120
" " " 25 " " " "	£85	£90	£100	£120	£130	£142

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

STANDARD CHAIN AND DISC PUMPS, for moderate lifts are as represented in Fig. 2594, but provided with gun-metal bearings for the disc shaft, and pulley for driving strap in lieu of the handle.

PRICES OF POWER DRIVEN STANDARD CHAIN AND DISC PUMPS.

Diameter of barrel inches	3	3½	4	4½	6
Price of pump 12 feet under spout ...	£5 10	£6 10	£9 10	£14	£19
„ extra length per foot	4/-	4/6	5/6	9/-	13 6

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.



Fig. 2594.



Fig. 2595.

HAND POWER CHAIN AND DISC PUMPS, Figs. 2594 and 2595, worked by manual power, are used for raising clear or turbid water, liquid manure, sewage, etc. The construction is the same as Fig. 2593.

The double standard pump Fig. 2594 is neat in appearance and the enclosed downcast protects the worker.

The prices include the head and driving gear, chain and discs and rising main with bell mouth bottom for a height of 12 feet under the spout; but this length can be increased at the rates respectively mentioned.

PRICES OF DOUBLE STANDARD CHAIN PUMPS, Fig. 2594.

Diameter of barrel inches	2	2½	3	3½
Capacity, gallons per hour	800	1500	2500	5000
Price of pump, 12 feet under spout ...	£4 5	£4 15	£5 5	£6 10
„ „ extra length, per foot	4/9	5/3	6/-	7/4

PRICES OF OPEN BACK CHAIN PUMPS, Fig. 2595.

Diameter of barrel inches	2	2½	3	3½
Price of pump, 12 feet under spout ...	£3 15	£4	£4 5	£5 10
„ „ extra length, per foot	3/7	4/-	4/3	5/3

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

HYDRAULIC RAMS.

HYDRAULIC RAMS.—Fig. 2596 represents one of several forms in which the hydraulic ram is made for providing a constant supply of water for small towns, mansions and outbuildings, factories, railway stations, etc. The necessary power is obtained by utilising a

given volume and fall of water for forcing a smaller volume to a considerable distance and height. To accomplish this, the driving water is passed through a cast-iron air-tight chamber provided with an air vessel and valves of the areas suitable respectively for the large quantity of driving water, and the relatively smaller quantity of water delivered at the height and distance required.

The hydraulic ram is entirely automatic and almost noiseless in action and works continuously without attention. The working parts are of hard gun-metal, and run for an indefinite time with very small expense for maintenance.

The duty of hydraulic rams cannot be defined until all the circumstances are known, the quantity raised varying in proportion with the fall of drive water and height of final delivery, but the following remarks on approximate proportions, afford general information on this subject.

Approximate proportions of hydraulic rams.—In estimating the size of ram required for a given duty in height and distance delivered with a given volume of drive water, it may be assumed that :

About one-seventh part of the water flowing into the ram will be raised to five times the height of fall from the stream or spring to the ram, or that :

About one-fourteenth part will be raised to ten times the height of fall.

It follows, therefore, that with a supply of 50 gallons per minute and a head (or fall) of 10 feet, the ram will deliver about 7 gallons per minute to a height of fifty feet, or $3\frac{1}{2}$ gallons per minute to a height of 100 feet, and so on. The length of horizontal delivery pipes is almost immaterial provided that they are of ample diameter.

A ram may be used where the fall does not exceed 18 inches, but the greater the fall the smaller is the quantity of water run to waste.

Site for fixing.—In selecting this, care should be taken to secure a continuous supply of driving water and a free escape of the waste.

In cold climates it is convenient to fix the ram in a pit or to surround it by a house to protect it from frost, dust, etc. ; the supply and delivery pipes being laid at such a depth below the surface as will effectually protect them from frost or from damage by passing vehicles.

The rising main should be as straight as possible, unnecessarily sharp bends being avoided.

Approximate prices.—As already indicated the cost of a hydraulic ram cannot be accurately determined until all the working conditions have been examined, but the following prices of rams of dimensions in common use, in conjunction with the remarks on capacity in relation to fall, may be useful.

The under-named approximate quantities are raised in 24 hours, to a height of 100 feet, according to fall. The prices do not include the large stop valve on the inlet pipe.

The spare parts include all that are subject to wear, such as spare dash valves and rubbers for valves, and will suffice for a considerable time.

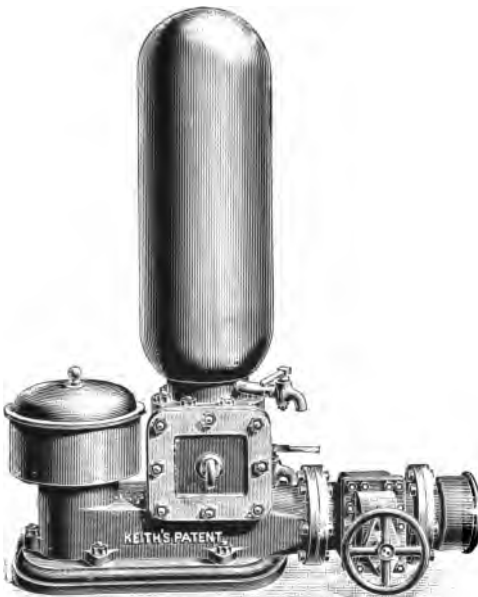


Fig. 2596.

PRICES OF HYDRAULIC RAMS, Fig. 2596.

Approximate capacity, gallons per 24 hours, 100 feet lift ...	from 100 to 1 1/2 inches	500	1000	2000	4000	8000	50000
Diameter of drive pipe ...	1 1/2 to 2 inches	100	200	400	800	1600	8000
Price of ram ...	...	£10	£13	£18	£26	£40	£100
„ spare parts ...	...	£3	£4	£5	£6	£8	£20

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

HYDRAULIC RAM PUMPS TO WORK WITH IMPURE DRIVE WATER.—Another form of ram pumps (not illustrated) admits of the use of impure or foul drive water for raising the pure water without possibility of contamination.

PRICES OF HYDRAULIC RAM PUMPS FOR IMPURE DRIVE WATER.

Approximate capacity, gallons per 24 hours, 100 feet lift ...	from 400 to 500 inches	2000	4000	8000	50000
Diameter of drive pipe ...	2 1/2 to 3 inches	400	800	1600	8000
Price of ram pump ...	...	£28	£40	£60	£150
„ spare parts ...	...	£5	£6	£8	£20

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

BORE HOLE AND TUBE WELL PUMPS.

PUMPS FOR PETROLEUM WELLS are generally similar to that illustrated by Fig. 2597. The prices relate to pumps of from 2 to 3 inches internal diameter with a stroke of about 5 feet, constructed as follows:—

The pump.—The barrel is of gun-metal, with the necessary valves, etc. The pipes are of wrought iron with flush screwed joints, and the rods reach from the pump to the surface. The head is of cast iron, with cast iron cover and stuffing box.

The head gear consists of a quadrant or “Bob” lever, with steel tension bars, steel gudgeons, pedestals and gun-metal bearings similar to that illustrated in Fig. 2506, wrought iron connecting rods, wrought iron joints for sweep rods and provision for counterbalance.

Motive power.—The cost of a steam engine and boiler, with accessories and pulley or provision for attachment of sweep rods, is usually from ... £200 to £300

Horse gear, with pulley or intermediate motion and accessories cost about £25 to £40

PRICES OF PUMPS FOR PETROLEUM WELLS.

Diameter of pump ...	... inches	2	2 1/2	3
Price of pump for a depth of 200 feet	...	£85	£100	£110
„ „ „ 300 „	...	£105	£120	£135
„ „ „ 400 „	...	£125	£145	£160
„ „ „ 500 „	...	£140	£175	£190
„ „ „ 600 „	...	£160	£185	£220
„ „ „ 700 „	...	£175	£205	£245

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

BORE-HOLE WELLS AND PUMPS.—A steady supply of water is obtained by boring in carefully selected ground and inserting the pump and rising main with flush joints, or by putting down a lining tube and suspending the pump as illustrated in Fig. 2597, the object, in both cases, being to maintain the bore and effectually shut out impure surface water.

Dimensions of wells.—Bore holes are made of all diameters from $2\frac{1}{2}$ to 24 inches and to the depth necessary to reach the water-bearing strata; they are put down in much less time and at far less cost than wells of the ordinary type (Fig. 2517, etc.) and—within certain limits—the larger the diameter, the better should be the results.

Cost of water supply.—Enormous quantities of water are raised from these wells at a cost—including fuel, labour, and contingencies—rarely exceeding one penny per 1000 gallons.

Depth of wells.—The bore-hole is usually driven through the water-bearing strata, as seen in the engraving, instead of just to it, as in ordinary wells. Increased depth frequently doubles the supply, and is attained at little additional cost.

The cost of bore-holes depends largely on the character of the ground, the depth, and other conditions, but they can be made of 3 to 4 inches diameter in most water-bearing strata, to a depth of 40 to 50 feet, at a cost of about 11/- per foot, increasing to 12/- to 14/- for greater depths.

The cost of lining tubes of usual dimensions will be found at page 119.

BORE-HOLE PUMPS of the type Fig. 2597 are single acting, and are attached to the lower end of a wrought iron rising main pipe with screwed joints, flush inside and out.

The pump rods (guided at intervals by turned and bored guards) are of wrought iron of special quality, with improved joints which cannot become loose. The top of the rising main is secured to the base which carries the pumping gear or direct acting engine, as the case may be.

The pump head gear may be driven by steam, cattle, or other power in connection with a crank, or a Quadrant ("Bob lever") similar to Fig. 2506.

The most satisfactory mode of driving, however, is by a direct-acting high-pressure engine, or a compound and condensing engine fixed directly over the bore and coupled to the pump rod.

Cost of bore pumps.—Although this cannot be ascertained until the dimensions, point of delivery, nature of plant, etc. have been determined, the following approximate prices of pumps, to deliver at the surface, may be useful as a basis for provisional estimate; it will be understood that the dimensions given on the next page are frequently very largely exceeded both in diameter and depth of pumps.



Fig 2597.

Pumps to deliver to a height above surface should be provided with an air vessel, back pressure valve, etc. which are not required for those last referred to.

PRICES OF BORE-HOLE PUMPS.

Internal diameter of pumps ... inches	4	5	6	7	8
Capacity, gallons per hour... ..	2500	3500	5000	7000	8500
Depth of pump feet	50	50	50	70	75
Price of „	£120	£140	£190	£240	£330
„ for extra depth per foot	24/-	27/-	30/-	35/-	45/-

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

HAND POWER BORE PUMPS, for domestic and similar purposes, consist of wrought iron lining tube for bore of four inches diameter, internal pump pipe of three inches diameter, gun-metal working barrel of $2\frac{1}{4}$ inches internal diameter, pump rods and pump head of the type Fig. 2598, all fitted ready for erection.

The price of pump above described for a depth of 30 feet is £25

TUBE WELL PUMPS illustrated by Fig. 2598, always provide a supply of water where the ordinary process of well sinking or boring would be successful, and even where these would fail or present difficulties, as in quicksand. The short time in which a tube well can be available for water supply is also a strong recommendation, more especially where only temporarily required as in expeditions (such as that referred to below) where the sanitary conditions are so largely influenced by an ample supply of water.

The water bearing strata suitable for tube wells are the coarse sand, gravel and chalk formations. The tube cannot be driven in rock and, as is well known the results in clay and marl are rarely satisfactory.

Position of pumps.—If the water is always within 25 feet of ground level, the pump is fixed at the surface; below that level, the pump must be in the tube at (or near) water level as shown in Fig. 2597.

The pump Fig. 2598 is one of a number which were successfully used during an expedition in Darfur.

The tube well staff were natives and the requisite number were sent in advance with tube driving apparatus similar to that illustrated in Fig. 2600 to provide the water supply at the site for the next camp. The rest of the staff remained with the camp and (when it was broken up) the pumps, tubes, etc. were withdrawn for future use.

Artesian supply.—Where water is obtained by simply driving a tube to the water bearing strata, the supply is controlled, by a cock or valve at a convenient height above the surface.

Capacities of tube well pumps.—These vary widely and are affected by pumping power relatively with the height of lift and (of course) by the strength of the spring which yields the supply, but under favourable conditions the quantities given in the table of dimensions, prices, etc. will be approximately correct.

Supplies beyond the capacity of a single pump, or where the water bearing capacity of the strata is weak, are obtained by driving a number of tubes. These are frequently connected at the surface by pipes, to a pump driven by steam, wind, animal or manual power.



Fig. 2598.

TUBE WELL PUMPS of the type Fig. 2598 consist of a pump head similar to that illustrated, a steel pointed perforated driving tube and wrought iron rising main with screwed steel socket connections for a total lift of 15 feet.

A spare steel driving point, as shown in Fig. 2599, with perforated tube about 3 feet long, or one with a sand strainer which is sometimes required.

A special metal perforated tube is only necessary where the soil or water corrodes iron.

For prices of steam and other driving gears for pumps, see pages 19 to 37.

PRICES OF TUBE WELL PUMPS, Fig. 2598.

Diameter of drive tube, inches	1½	1½	2	3	4
Approx. capacity, galls. per hour	150 to 500	200 to 700	300 to 1000	500 to 2000	1000 to 4000
Price of tube, with drive point, for 15 feet lift ...	£1 10	£2	£2 10	£5	£6
Price of pump head ...	£2 10	£3	£3 10	£5	£6
Extra drive pipe, per foot ...	1/3	1/7	2/6	4/-	5/-
„ drive tube point, about 3 feet long	12/6	15/-	20/-	40/-	60/-
„ „ with sand strainer	22/-	28/-	35/-	65/-	105/-
„ „ special metal ...	30/-	35/-	55/-	80/-	120/-

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.



Fig. 2599.

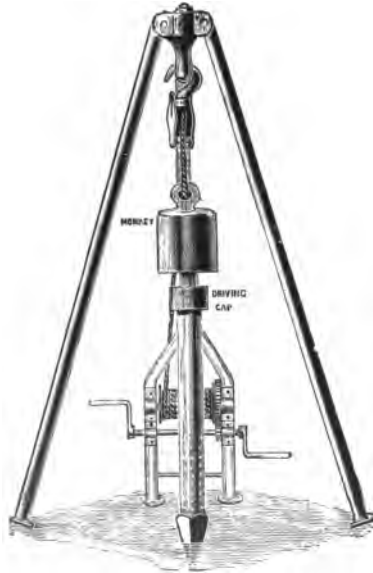


Fig. 2600.



Fig. 2601.

TUBE WELL DRIVING APPARATUS, illustrated by Figs. 2599 and 2600, consists of the driving head which is attached, in the first instance to the perforated drive tube with steel point and afterwards to the well tube, the ram or "monkey" and the well tube being supported by the tripod, as in Fig. 2600, or by other means.

TUBE WELL DRIVING TRIPOD WITH WINCH.—Fig. 2600 represents an improved form of those used in the expedition referred to on the preceding page, for putting down and withdrawing tube wells for water supply, and consists of tubular wrought-iron tripod with feet to take a bearing, one leg being provided with a winch which is used for raising the monkey in driving and for drawing tubes when required.

A cross head with loop for a pulley block connects the legs at the upper end, and as will be seen, they are undamageable and easily erected or removed. The apparatus is complete with lifting block, rope or chain, monkey and driving cap to attach to the drive tube. The drive tube is not included, but the cost of each size will be found in the preceding table.

PRICES OF ROTARY PUMPS, Fig. 2602.

Capacity, gallons per hour	300	500	700	1200	1900	2700
Diameter of pipes inches	1	1½	1½	2	2½	3
Price of power-driven pump... ..	£2 10	£3 10	£4 5	£5	£7	£10
„ hand-power „	5/-	6/-	7/-	9/-	12/-	15/-
Extra for air vessel						

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

THE DOWNTON ROTARY SHIP'S PUMP OR FIRE ENGINE, Fig. 2603, has been generally used for many years by H. M. Navy and in the Merchant Service, and is made principally of gun metal. A treble crank works three buckets, rods, and slides, and the suction plate and "goose neck" are so arranged that water may be drawn from the sea or from any one of three or six compartments. The pump is supplied with a heavy fly-wheel and wrought-iron handles, as shown in the engraving, and may be driven by manual power or by a messenger chain from the steam winch or donkey engine.

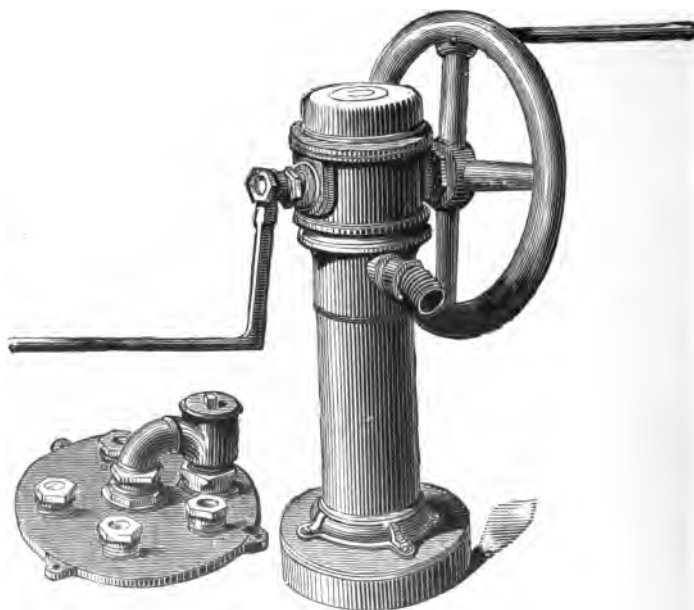


Fig. 2603.

PRICES OF DOWNTON ROTARY PUMPS, Fig. 2603.

Diameter of pump inches	4½	5	5½	6	7
„ delivery hose	1½	1½	2½	2½	2½
Capacity, galls per hour... .. about	2000	2500	3250	3900	5000
Price of pump	£22	£27	£32	£35	£40
„ suction plate 3 compartments	£4	£5	£5	£7	£7
„ „ 6 „ „	£5	£6	£6	£9	£9
„ messenger chain wheel	30/-	35/-	40/-	45/-	50/-

THE NAVY ROTARY PUMP is similar externally to Fig. 2603, but improvements have been made in the internal construction, and as will be seen from the subjoined lists, the duty is higher than that of the Downton pump. The suction plate as usually supplied is arranged for drawing from the sea, or from any of three compartments.

PRICES OF THE NAVY ROTARY PUMP.

Diameter of pump inches	3½	4½	5½	7
„ delivery hose „	1½	2½	2½	3½
Capacity, galls. per hour about	2500	4000	6500	10,000
Price of pump	£23	£28	£38	£50
„ suction plate, 3 compartments	£5	£7	£9	£16

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

DUPLEX COLONIAL PUMPS.—Fig. 2604 illustrates pumps to work by cattle or engine power which were originally designed for raising the water supply for cattle when travelling in the interior of Australia.

Most of the localities where these pumps were put down were far distant from inhabited districts and it was essential that they should be self contained, strong enough to withstand the roughest usage, and that all parts should be easily accessible for examination. A reference to the engravings and the following brief description will show how these conditions have been completely fulfilled.



Fig. 2604A.

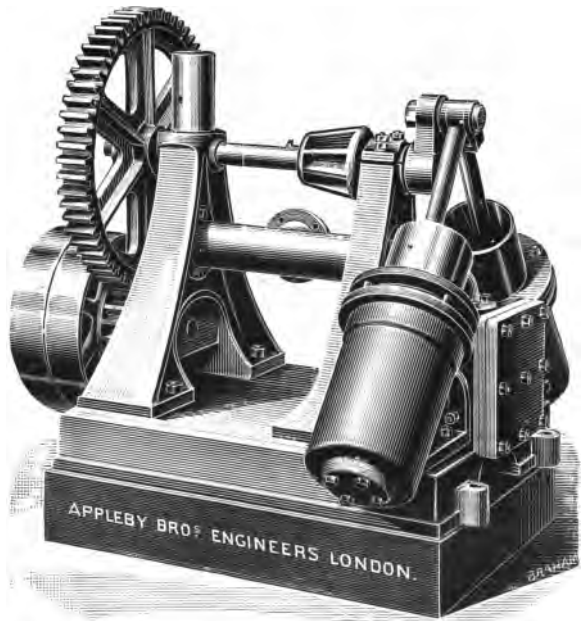


Fig. 2604.

The duplex pumps consist of a pair of barrels fixed diagonally to one of the standards which are bolted to a strong cast-iron base plate of box section. The trunk plungers are fitted with gun-metal bushed glands and the pump connecting rods are driven from the crank on the end of the main shaft.

Pumps worked by belt have a spur wheel on the main shaft, driven by pinion and pulleys on the lower shaft.

For working by animal or manual power the spur gear and pulleys are omitted and the crown wheel, with four pockets for draft poles (Fig. 2604A), is carried on the vertical bearing and transmits motion to the pumps through the bevil pinion shown in the engraving.

Suction and delivery connections.—The suction pipe is fixed to a branch with flange below the valve box ; the delivery pipe forms a stay between the two standards and is also provided with a flanged outlet. For prices of pipes see pages 125, etc.

PRICES OF DUPLEX COLONIAL PUMPS, Fig. 2504.

Diameter of pump barrels inches	6	7	8
" pipes "	4	4½	5
Approx. capacity, gallons per hour	3500	4500	5500
Price of pump driven by belt, Fig. 2603	£44	£50	£57
" " to work by cattle	£38	£44	£50
" cattle poles	22/-	25/-	30/-
Approx. measurement cubic feet	80	90	120

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

PORTABLE LIFT AND FORCE PUMPS DRIVEN BY CATTLE GEAR.

—Fig. 2605 represents an arrangement of pumping plant to raise water from a depth not exceeding 25 feet, for irrigation in India where it was necessary that they should be worked and maintained by natives.

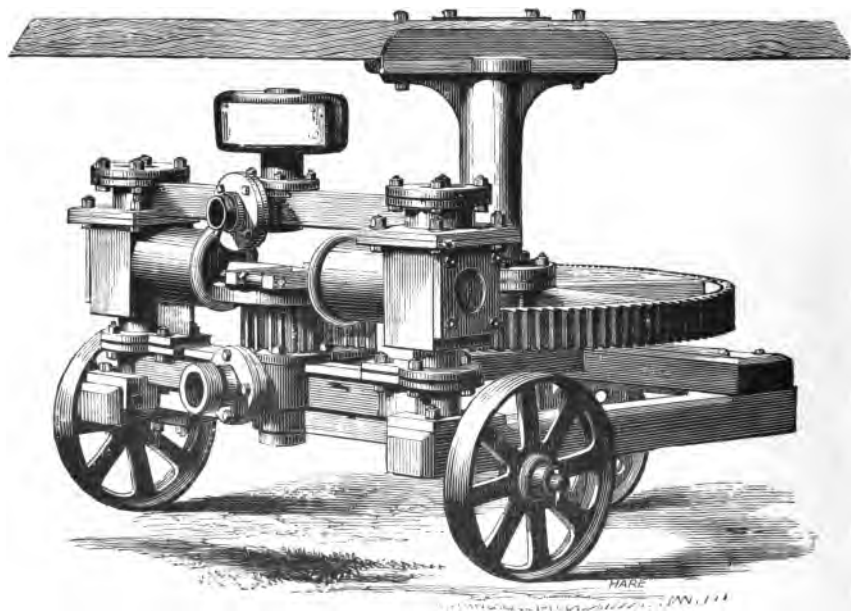


Fig 2605.

The double-barrel pumps are of cast iron with an air vessel (not shown in the engraving) over each valve chamber ; the valves are of the grid type, with plain india rubber or leather discs and brass guards.

The suction and delivery connections are hose unions for portable pumps ; fixed pumps usually have flanged connections.

The **driving gear**, worked by two or more oxen, consists of the large spur wheel and pinion, with disc plate and crank pin on the upper side which transmits motion to the cross head. The cattle poles are provided with whipple trees and serve as draft poles when the pumps are moved.

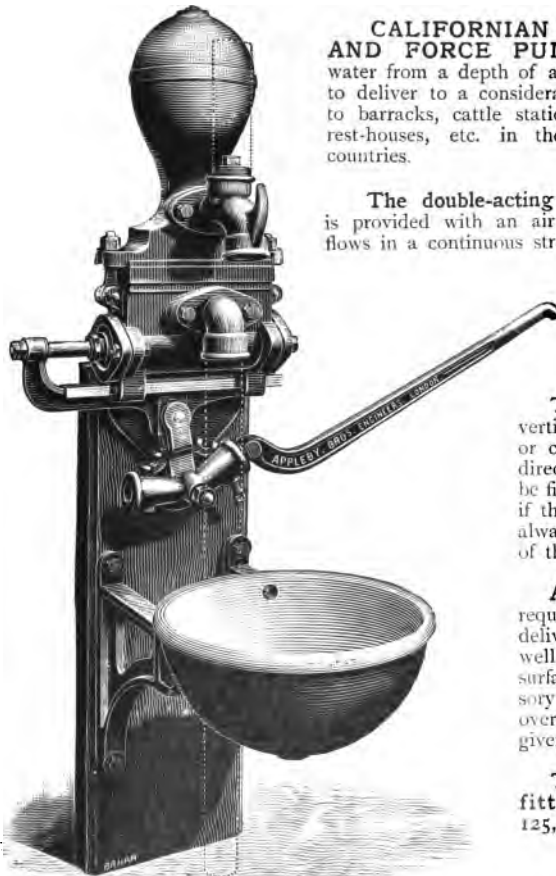
For **travelling long distances** the carriage is mounted on four wheels larger in diameter and width than those shown in the engraving, and provided with a swivelling fore carriage.

The **approximate pumping capacities** are obtained with cattle travelling at a speed of 2 to 3 miles per hour.

PRICES OF PORTABLE PUMPS WITH CATTLE GEAR, Fig. 2605.

Diameter of pumps ... inches	3	4	6	8
„ suction pipe... „	2	2½	3½	5
„ delivery „ ... „	1½	2	3	4
Capacity, gallons per hour, about	500 to 700	1000 to 1300	3000 to 4000	5000 to 7000
Price of pumps, Fig. 2604 ...	£30	£35	£45	£60
„ without wheels...	£28	£32	£42	£55

The cost of packing for shipment and delivery f.o.b. is 5 per cent.



CALIFORNIAN DOUBLE-ACTING LIFT AND FORCE PUMPS of the Fig. 2606 raise water from a depth of about 25 feet, and are arranged to deliver to a considerable height for supplying water to barracks, cattle stations, wayside watering stations, rest-houses, etc. in the Colonies, India and other countries.

The double-acting pump works noiselessly, and is provided with an air vessel from which the water flows in a continuous stream. The valves and working parts can be taken apart for examination and replaced in a few minutes by an unskilled workman, and the handles are easily fixed or removed.

The suction pipe may be vertical (as indicated by dotted lines) or carried in any more convenient direction. A retaining valve should be fixed on the bottom of the pipe if the pump is to be kept charged, always ready for work. The cost of this is given below.

A three-way cock is only required for pumps which must deliver into buckets or the basin, as well as force to a height above the surface. The prices for this accessory and for the basin, with plug, overflow outlet and brackets, are given separately.

The prices of pipes and fittings will be found at pages 125, etc.

Fig. 2606.

PRICES OF CALIFORNIAN DOUBLE ACTING PUMPS, Fig. 2606.

Diameter of pump barrel inches	2½	3	4	5	6
„ water pipes „	1½	1½	2	2½	3
Approximate capacity, gallons per hour ...	360	600	1020	1620	2500
Price of pump without three-way cock ...	£4	£4 15s.	£6 15s.	£8 15s.	£12
Extra for three-way cock	20/-	21/-	27/6	35/-	50/-
„ handles	3/6	4/-	5 6	6/-	7/6
„ basin and brackets	17/-	17/-	25/-	25/-	35/-
„ for copper-lined barrel	6/-	7/6	9/-	10/6	13/-
„ foot-valve and strainer	10, 6	11/-	12/-	13/-	14/-

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

PORTABLE CALIFORNIAN PUMPS.—Fig. 2608 represents the pump mounted on a barrow, but otherwise constructed as described on the preceding page. The larger sizes are also fixed on a carriage with swivelling front wheel and double handles for six men.

As a first aid Fire Engine the Californian pumps have often rendered excellent service in extinguishing fires, although originally provided for the numerous purposes for which pumping power is ordinarily required. They will raise water from a maximum depth of about 25 feet and deliver a continuous stream to a height of about 50 feet, or horizontally to a great distance.

The suction and delivery pipes may be of wrought iron or flexible hose; the prices of these and other fittings such as unions, nozzles, branches, etc. will be found at pages 123, etc.

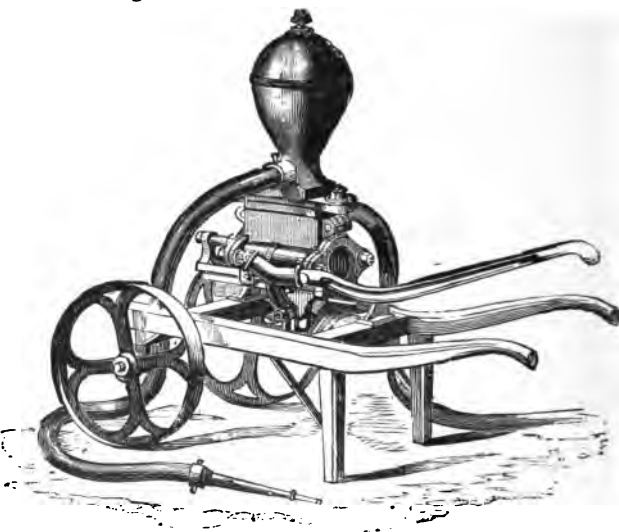


Fig. 2608.

PRICES OF PORTABLE CALIFORNIAN PUMPS.

Diameter of pump barrel inches	5	6
Price of pump, Fig. 2607	£18	£22
„ „ on four wheels	£19	£23
Extra for barrel copper lined	45/-	50/-

The cost of packing for shipment and delivery f.o.b. is about 7 per cent.

PRICES OF CALIFORNIAN PUMP ON BARROW, Fig. 2308.

Diameter of pump barrel inches	2½	3	4	5	6
Price of pump with handle	£6	£7	£9	£13	£17
Extra for barrel, copper lined	7/-	8/-	9/-	11/-	14/-

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

WROUGHT IRON PUMPS.

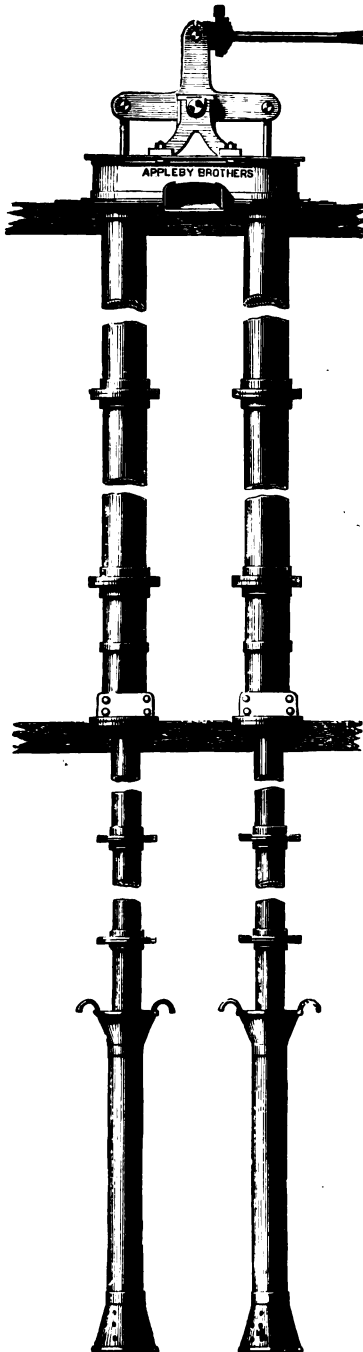


Fig. 2610.

MINE OR DEEP WELL PUMPS represented by Fig. 2609 are made for depths up to about 300 feet and with open top as illustrated or with closed top and stuffing box for forcing to a height above the surface. They are always specially designed and are rarely less than six inches diameter, usually with long stroke.

The pump head is of wrought iron and (if required for sinking in the first instance) the top length of rising main is turned and provided with a stuffing box which admits of the pump being lowered to follow the excavation.

The cast iron working barrel is fixed near to water level and is provided with a door for access to the valves which, as will be seen, are of the Cornish type and suitable for permanent service. The rising main is slightly larger in diameter than the pump and is usually of steel with faced flanges.

WROUGHT IRON SINKING PUMPS, of the type Fig. 2610, are made with single and double barrels and are used for raising water from deep workings in trench, mine, or other sinkings.

The pump head is of wrought iron and the working barrel is of cast iron, with door for access to valves and is lowered to near water level.

The rising main and suction pipes are usually of steel, the bottom length with strainer being as shown in the engraving, to follow the excavation until another length is required.

The quadrant piece is of wrought iron and is complete with wrought iron work to attach to the rod for connecting to an intermediate gear, see Fig. 2521.



Fig. 2609.

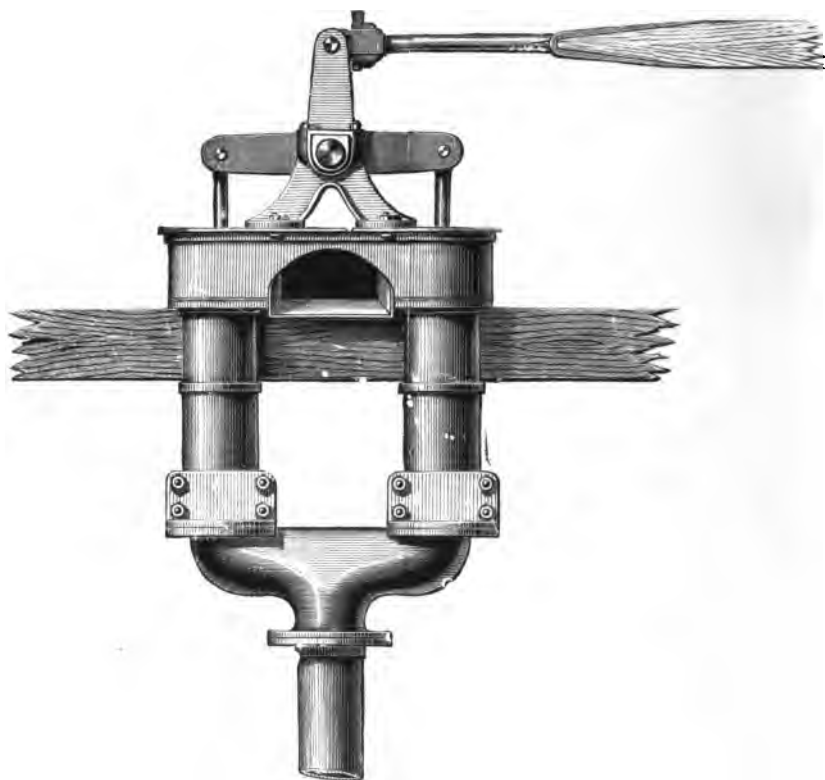


Fig. 2612.

DOUBLE BARREL WROUGHT IRON PUMPS, Fig. 2612, to work by steam or hand power, are adapted for pumping from a depth not exceeding 28 feet from the surface, and are much used for clearing water from foundations.

A pair of cast-iron barrels, with doors for access to valves, are attached to a wrought iron pump head, which carries the rocking lever for working the pumps. The buckets are of cast iron packed with hemp, and are easily drawn out for examination or repacking.

The suction pipe is of wrought iron with faced flanges, and the bottom length is provided with a sliding suction pipe similar to that shown in Fig. 2610, to work to a total depth of 28 feet under the spout.

The capacities in gallons per hour are for a working speed of 30 strokes per minute. The maximum size of pump which should be worked by hand power is 10 inches diameter.

The prices include the wrought iron connecting rod with adjustable bearing, or strong wrought iron double lever handles for working by hand power.

PRICES OF DOUBLE BARREL WROUGHT IRON PUMPS, Fig. 2612.

Diameter of pump inches	6	8	10	12	15
Capacity, gallons per hour about	4000	9000	15000	34000	65000
Price of pump with doors to valves ...	£28	£45	£67	£89	£124
„ without doors to valves ...	£25	£40	£64	£85	£119

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

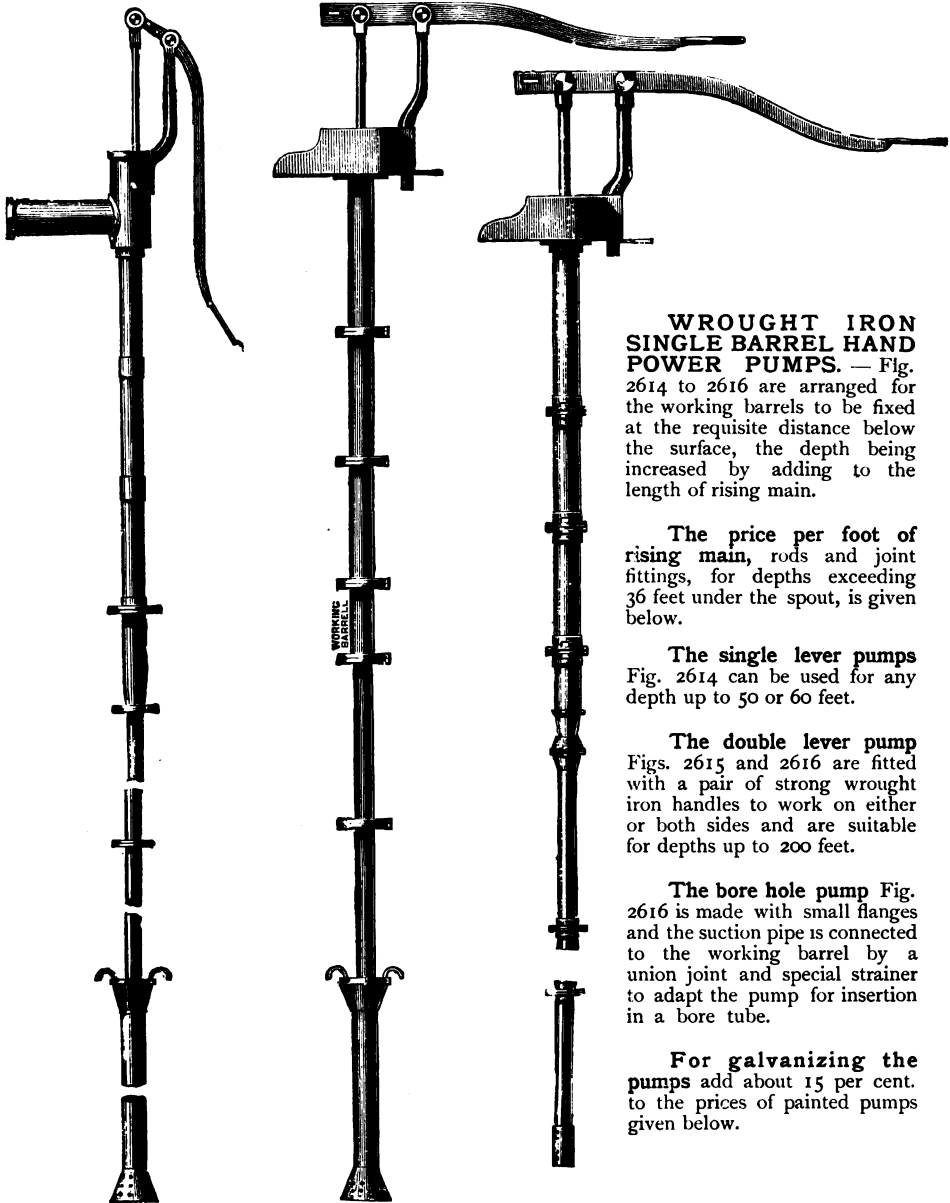


Fig. 2614.

Fig. 2615.

Fig. 2616.

WROUGHT IRON SINGLE BARREL HAND POWER PUMPS. — Fig.

2614 to 2616 are arranged for the working barrels to be fixed at the requisite distance below the surface, the depth being increased by adding to the length of rising main.

The price per foot of rising main, rods and joint fittings, for depths exceeding 36 feet under the spout, is given below.

The single lever pumps
Fig. 2614 can be used for any depth up to 50 or 60 feet.

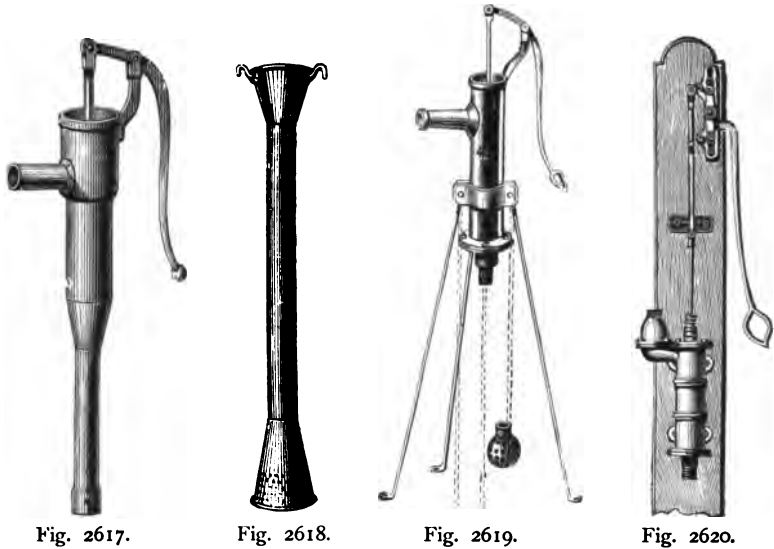
The double lever pump
Figs. 2615 and 2616 are fitted with a pair of strong wrought iron handles to work on either or both sides and are suitable for depths up to 200 feet.

The bore hole pump Fig. 2616 is made with small flanges and the suction pipe is connected to the working barrel by a union joint and special strainer to adapt the pump for insertion in a bore tube.

For galvanizing the pumps add about 15 per cent. to the prices of painted pumps given below.

PRICES OF SINGLE BARREL PUMPS, Figs. 2614 and 2615.

Diameter of working barrel ... inches	4	5	6	7	8
Price of pump Fig. 2614 for 36 ft. depth	£9	£11	£13	£16	£19
" Fig. 2615 " "	£14	£16	£18	£22	£27
" pipes, etc. for extra depth per foot	5/6	6/6	7/6	9/-	11/6



WROUGHT IRON LIFT PUMPS illustrated by Fig. 2619 and 2620 are strong and light, and are much used by Builders, for Farm purposes, and for raising liquids containing gritty or other insoluble matter. The maximum lift is 28 feet. The buckets are made of hard wood with leather packings and valve faced with leather, all easily renewed.

The pump Fig. 2619 is of wrought iron, painted or galvanized, and is made in lengths up to 14 feet below the spout, but more frequently from 7 to 9 feet. The buckets and valves are as above described.

The sliding suction pipe Fig. 2618 is usually 8 feet long, with strainer at bottom and lugs for slinging it at the depth required. The joint around the pump suction pipe is made quite well with wet clay or hemp.

PRICES OF WROUGHT IRON PUMPS AND SUCTION PIPES, Figs. 2618 and 2619.

Diameter of working barrel ... inches	3	4	5	6	7	8	9
Height under spout ... feet	7	7	7	8	9	9	9
Price of pump painted	40/-	45/-	49/-	59/-	82/-	100/-	115/-
„ sliding suction	25/-	27/6	33/-	35/-	43/-	51/-	60/-
„ pump galvanised	42/-	50/-	54/-	65/-	92/-	112/-	130/-
„ sliding suction	27/6	31/6	37/-	39/-	47/-	60/-	70/-
Extra suction pipe painted per foot	1/9	1/10	2/-	2/4	2/8	3/2	3/9
„ „ galvanised „	2 -	2/1	2/4	2/6	3/2	3/8	4/3

TRIPOD GALVANIZED IRON LIFT PUMPS, Fig. 2619, to raise from a depth of 28 feet and deliver at the surface, are fitted as last described, but are mounted on a wrought iron tripod stand and provided with screwed connection for wrought iron suction pipe or flexible hose.

PRICES OF TRIPOD GALVANIZED IRON LIFT PUMPS, Fig. 2619.

Diameter of pump inches	3	4	4½	5
Price of pump	£2 2	£2 5	£2 10	£2 15
„ india-rubber suction hose, per foot	2/-	2/6	2/6	3/6
„ strainer and binding in	3/6	4/-	4/-	4/6

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

TRIPOD GALVANIZED IRON LIFT AND FORCE PUMPS are fitted with closed top and stuffing box for the pump rod, as required for forcing, but are otherwise so nearly like Fig. 2619 that they need not be illustrated. The suction and delivery pipes may be wrought iron or flexible hose.

PRICES OF TRIPOD GALVANIZED IRON LIFT AND FORCE PUMPS.

Diameter of pump inches	3	4	4½	5
Price of pump	£4 10	£4 15	£5 5	£6
„ rubber suction and delivery hose, per foot	2/-	2/6	2/6	3/6
„ strainer and binding in	3/6	4/-	4/-	4/6

PLANK LIFT AND FORCE PUMPS of the type Fig. 2620, lift from a maximum depth of 28 feet and deliver to a height of 25 to 70 feet according to the diameter of the working barrel. The pumps are made with either brass or iron barrels, and are fitted with brass union joints for both suction and delivery pipes.

PRICES OF BRASS LIFT AND FORCE PUMPS, Fig. 2620.

Diameter of pump... ..	2	2½	3	3½	4
Price of pump, with brass barrel...	£3 15	£4	£4 10	£6 10	£8 10
„ „ iron barrel	£2 17	£3	£3 10	£4 10	£6 10

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

HAND POWER HOUSE PUMPS.

APPLEBY'S HAND POWER PUMPS.—Fig. 2621 to 2627, illustrate only a few of the forms in which these useful and reliable pumps are made; the feature in all is that they are fitted with the self-adjusting valve and bucket indicated in Fig. 2621 and retaining valve (Appleby's patent), which are (practically) indestructible and maintain a vacuum, even when pumping liquids charged with grit or other insoluble matter.

The pumps Figs. 2622 and 2623 are suitable for deep wells and Figs. 2624 to 2627 for drawing from any depth not exceeding 25 feet from the base of the barrel.



Fig. 2621.

The pump barrels are of close grained cast iron, truly bored and tapped for pipes of the diameters specified, or for hose, lead, or other convenient connections.

The adjustable cap admits of the handle being fixed in any convenient position relatively with the spout. The fixed caps have the handle in line with the spout as shown in Fig. 2623.

The suction pipes must be air tight and should (in most cases) be provided with foot valve and strainer.

For prices of pipes hose and other fittings see pages 122, etc.

PUMPS FOR RAISING OIL or liquors containing fatty matter, and some chemicals, must be specially constructed. This usually involves a little extra cost and the work to be performed should be clearly defined.

PUMPS FOR DEEP WELLS of the types Figs. 2622 and 2623 raise water from depths not exceeding about 100 feet and are adapted respectively for forcing to a considerable height or for delivering at the surface only, but many modifications in the arrangements for both purposes must remain unillustrated.

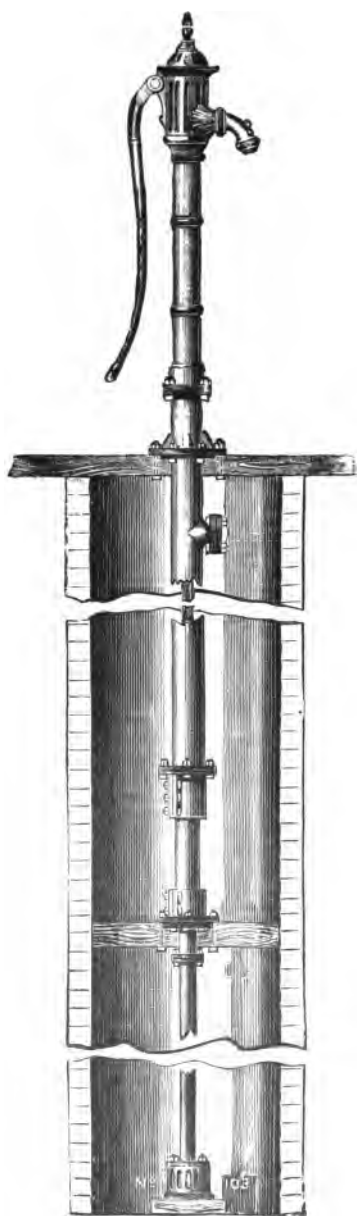


Fig. 2622.

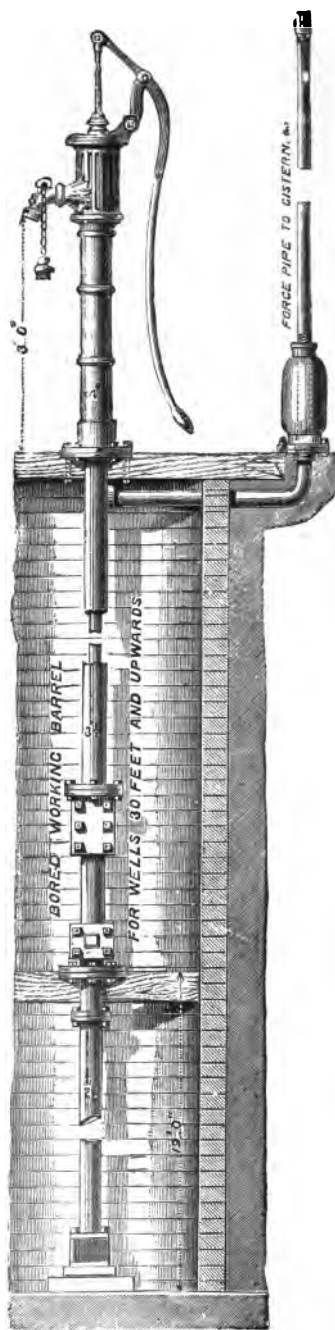


Fig. 2623.

LIFT AND FORCE PUMP FOR DEEP WELLS, Fig. 2622, raise from a depth of about 100 feet, and will force to a considerable height; when fixed as illustrated the standard head acts as an air-vessel of large capacity and increases the efficiency of the pump. If delivery is required at the surface, the brass plug is removed as indicated in the engraving.

The **working barrel** is bored and fitted with self-adjusting valve and bucket, brass connection to the pump rod, retaining valve and doors for access to both bucket and retaining valve. The bottom of the suction pipe is provided with a foot valve and strainer.

The **gland and stuffing box** are outside the cap and perfectly accessible for packing. The handle and vibrating links are of wrought or malleable iron.

The **prices for the pumps** include all accessories for a depth of 30 feet, but no delivery pipes. The cost of a pump for any other depth is obtained by simply adding (for the depth beyond 30 feet) at the rate tabulated for the respective diameters.

The **prices of delivery pipes** and fittings will be found at pages 122, etc.

PRICES OF LIFT AND FORCE PUMPS, Fig. 2622.

Diameter of working barrel inches	2½	3	3½	4
„ rising main and standard	3	3½	4	4½
Price of pump complete for 30 feet deep ...	£10 10	£11	£12 10	£13
„ pipes, rods, etc. for extra depth, per foot	2/7	3/1	3/8	4/3
„ for copper liner to working barrel ...	8/6	9/6	11/-	14/-

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

LIFT AND FORCE PUMPS for wells 27 feet deep and to force to a height of about 50 feet. The working barrel is fixed below the surface, as last described, but is of lighter construction and without suction pipe, foot valve and strainer.

PRICES OF LIFT AND FORCE PUMPS FOR 25 FEET WELLS.

Diameter of pump inches	2½	3	3½	4
Price of pump	£7 12	£8 4	£8 14	£9 15

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

LIFT PUMP FOR DEEP WELLS TO DELIVER AT THE SURFACE, Fig. 2623.—The working barrel, buckets, valves, etc., are similar to those above described (Fig. 2622), but the delivery is from the pump head only.

PRICES FOR LIFT PUMPS FOR DEEP WELLS, Fig. 2623.

Diameter of pump inches	3	3½	4
„ rising main and standard	3½	4	4½
Price for pump, complete for 30 feet deep ...	£8	£9 5	£10 10
„ pipes, rods, etc., for extra depth, per foot	3/1	3/8	4/3
„ copper liner to working barrel	9/6	11/-	14/-

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

WORKING BARRELS FOR DEEP WELL PUMPS are 30 inches long over all with buckets and valves as described for the pumps 2622 and 2623, and are made with two doors for access to both suction and delivery valves or with one to the suction valve only.

PRICES OF WORKING BARRELS FOR DEEP WELL PUMPS.

Diameter of pump inches	2½	3	3½	4	4½	5	6
Price of barrel with two doors ...	38/-	46/-	53/-	63/-	76/-	88/-	104/-
„ „ one „	27/-	32/-	38/-	46/-	51/-	63/-	...

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

PUMP PIPES, RODS, WELL STAGES, AND OTHER FITTINGS.—

The approximate cost of these, for any size or depth, is ascertained by reference to the prices given elsewhere. See pages 122 and forward.

LIFT PUMP FOR SHALLOW WELLS (not exceeding 25 feet deep).

The pump head is as illustrated by Fig. 2623 and is complete with Appleby's patent bucket and valves, but no suction pipes or fittings; the prices for these will be found at pages 125, etc.

The height under spout can be increased up to about 6 feet at a small additional cost.

PRICES OF LIFT PUMPS FOR SHALLOW WELLS, Fig. 2623.

Diameter of pump inches	2½	3	3½	4	4½	5	6
„ „ suction pipe „	1½	2	2½	2½	3	3½	4
Height under spout feet	3	3	3	4	4	4	6
Price of pump	£2 5	£2 13	£2 17	£3 6	£3 19	£5	£6 18
Extra, if copper lined	8/6	9/6	11/-	13/-	16/-	26/-	44/-

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

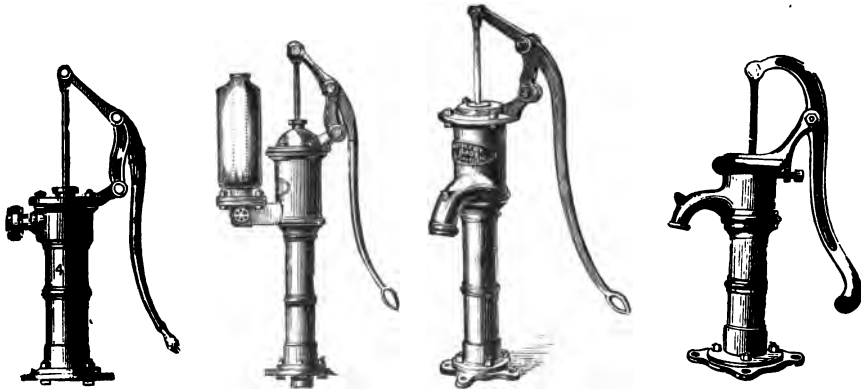


Fig. 2624.

Fig. 2625.

Fig. 2626.

Fig. 2627.

LIFT AND FORCE PUMPS WITH HORIZONTAL DELIVERY.—

Fig. 2624 are fitted with Appleby's valves and bucket, and are made with base as shown, or with bracket for bolting to a wall, plank or cart. The suction pipe is wrought iron, lead or flexible hose, usually the first named. The delivery branch is made with flange, unless otherwise directed.

The suction for these pumps should not exceed 25 feet.

PRICES OF LIFT AND FORCE PUMPS, Fig. 2624.

Diameter of pump inches	2	2½	3	3½
„ „ suction pipe „	1	1½	2	2
Height to delivery branch „	9	14	18	22
Price of pump	£1 15	£2 2	£2 13	£3 3

LIFT AND FORCE PUMPS WITH VERTICAL DELIVERY.

Fig. 2625 have the same dimensions and are fitted in the same manner as Fig. 2624, but provided with an air vessel on the delivery branch to equalise the flow and reduce vibration in working.

A tap on the delivery branch for drawing off at the surface costs about 6/6.

PRICES OF LIFT AND FORCE PUMPS, Fig. 2625.

Diameter of pump inches	2	2½	3	3½
Price of pump	£1 17	£2 13	£2 18	£3 14

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

LIFT PUMPS FOR WELLS NOT EXCEEDING 25 FEET DEEP.—Fig. 2626 have a reversible cap for adjusting the handle to any position and with base, as shown, or with brackets for bolting to a wall, plank, cart, etc.

PRICES OF LIFT PUMPS FOR SHALLOW WELLS, Fig. 2626.

Diameter of pump inches	2½	3	3	3½
„ suction pipe „	1½	2	2	2½
Height under spout „	13	18	24	36
Price of pump as illustrated	£1 12	£1 15	£1 18	£2 13
„ „ with bracket	£1 15	£1 18	...	...

UNIVERSAL PUMPS FOR LOW LIFTS, Fig. 2627, have reversible caps and Appleby's buckets and valves.

PRICES OF UNIVERSAL LIFT PUMPS, Fig. 2627.

Diameter of pump inches	2	2½	3
„ suction pipe „	1	1½	1½
Height of pump „	14½	16	21
Price of pump	15/9	19/-	25/6

COLONIAL PUMPS with base for bolting to timber or masonry, or with bracket for attachment to wall, etc. are similar to Fig. 2627, but are fitted with brass union for connection with wrought iron or other suction pipe.

PRICES OF COLONIAL PUMPS.

Diameter of pump inches	2	2½	3	3½
„ suction „	1	1½	1½	2
Height under spout „	8	9	10	11
Price of pump, with base plate	12/9	15/9	19/6	28/-
„ „ brackets	14/3	17/6	21/9	30/9

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

PITCHER PUMPS.—This well-known type has a reversible handle, brass seating and anti-freezing apparatus; the connection for suction is screwed for iron pipe, or tinned for lead pipe as required.

PRICES OF PITCHER PUMPS.

Diameter of pump inches	2½	3	3½	4
„ suction pipe „	1½	1½	2	2
Height under spout „	11	11	12	12½
Price of pump... ..	19/-	22/-	25/6	28/6

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

FIXED HYDRAULIC PRESSURE PUMPS.—Fig. 2628 represents a neat and self-contained pump equal to a working pressure of 2 tons per square inch, for use in connection with a small hydraulic press, lift, etc. The pump is of gun-metal, the plunger is $1\frac{1}{4}$ inch diameter, the valves and seats are of gun-metal, and the pump is fitted with safety valve and pressure gauge graduated to 2 tons per square inch, and removable lever.

For driving by power the pump is usually connected with an existing shaft, but the appliances are easily removed for working temporarily by hand.

The price of the pump
complete is £20
It with connections for driving by
power £22



Fig. 2628.

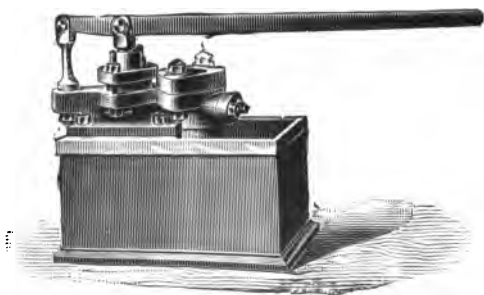


Fig. 2629.

PORTABLE HYDRAULIC TEST PUMPS.—Figs. 2629 to 2631 illustrate the types in general use for testing boilers, pipes, cylinders, and for many other purposes where the pressure required does not exceed about 300 lbs. per square inch.

The pumps and valves are of hard gun-metal, and the pump is complete with wrought iron handle and brass union on the delivery pipe.



Fig. 2630.



Fig. 2631.

The price of pump with rectangular base, Fig. 2629, is	...	...	...	£7 10 0
„ „ „ „ mounted on barrow, is	...	...	...	£8 15 0
„ „ cylindrical wrought iron base, Fig. 2630, is	...	...	...	£7 0 0
„ „ with wheels and swivelling fore-carriage, Fig. 2631 is	...	...	...	£10 10 0
„ of pressure gauge, graduated to 300 lbs. (or atmospheres), is	...	...	...	£1 0 0

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

Hydraulic pipe proving machine.—A useful machine for testing pipes by hydraulic pressure, consists of a cast iron bed fitted with headstocks for carrying appliances for quickly making the joint at each end of the pipe, and with differential plunger pumps, the large pump automatically ceasing to work when pressure is brought on the pipe. The water is conveyed into the pipe through the centre of the fixed headstock, and appliances are provided for getting rid of air.

The price of the machine to test straight pipes of any length up to 9 feet, and of any diameter up to 24 inches, is £150

If with apparatus for testing bends and irregular, as well as straight pipes, the price is £182

The approximate weight is 2½ tons, and the cost of packing for shipment is about 5 per cent

WATER PURIFYING APPARATUS.

PURIFYING AND SOFTENING WATER.—Strictly speaking, appliances for this purpose do not come under the category of “Pumping machinery,” but a copious supply of soft water, freed from injurious ingredients, is of such large commercial value in connection with steam boilers and many industrial operations, that it seems desirable to direct attention to the methods whereby the objectionable matter can be removed, with indications of those which are most efficient and economical.

Water heating.—Passing water through one of the numerous types of water heaters, see pages 46 to 48 of Section I, eliminates some ingredients, but others remain, and the hardness which is so objectionable in water used for feeding boilers and for washing is not removed.

Distillation (see Figs. 6182 to 6184 in Section VI.) as is well known, produces chemically pure water, but at a cost which usually precludes its use on the large scale necessary for Factory supply, Boiler feeding, etc.

Filtration removes impurities mechanically mixed with the water, but not those—such as sulphate of lime, carbonate of lime, etc.—which are in chemical combination with it. For this reason filtration can rarely be used with advantage.

The Chemical process, however, with filtration, economically removes the objectionable ingredients, whether mechanically or chemically combined, as will be seen from the following analyses of water, before and after treatment, in the Bruun water softening and purifying appliances illustrated by Figs. 2632 and 2633.

Before treatment the water contained per 100,000 parts :

Total solids at 100C.....	176.40	Chloride (Cl).....	26.25
Lime (CaO).....	39.20	Carbonic acid, total.....	65.78
Magnesia (MgO).....	8.49	Free and semi-combined	
Sulphuric acid (SO ₃).....	25.59	Carbonic acid (CO ₂).....	38.94

After treatment the same water contained per 100,000 parts :

Lime (CaO).....	0.50	Magnesia (MgO).....	2.16
-----------------	------	---------------------	------

The chemicals used in obtaining this result are universally procurable at a low cost and similar results are absolutely guaranteed, provided that a sample (one or two gallons) of the water has been sent for analysis.

WATER SOFTENING APPARATUS for quantities exceeding about 3000 gallons per hour are of the type Fig. 2632.

For smaller quantities (50 to 2000 gallons per hour) the apparatus is rectangular, as illustrated by Fig. 2633 and described further on.

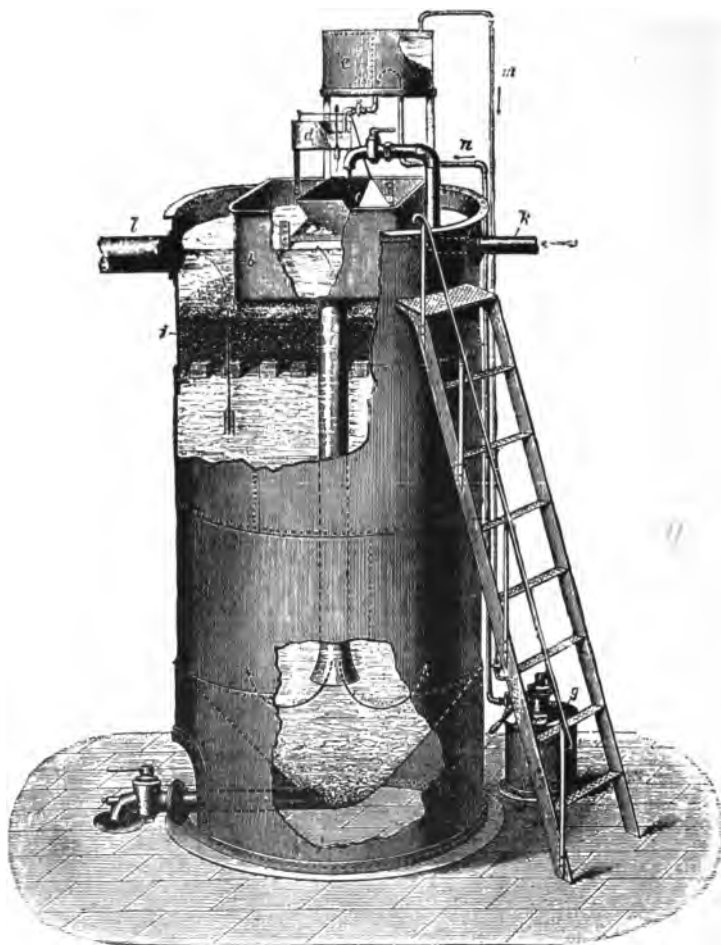


Fig. 2632.

The mode of working is identical in both types of apparatus and is as follows:

The water to be treated is conveyed by the pipe **k** into one of the chambers of the oscillating receiver **c**; this tips over when the chamber is filled, pours its contents into the mixing tank below and automatically returns into position below the pipe **k**. Every oscillation of the receiver actuates a valve, the extent of oscillation being adjustable to admit of a given quantity of chemicals being mixed with the water. The impurities are precipitated to the bottom of the tank **a** and removed through the cock **f** at intervals of four to six weeks. The pure water ascends through the filter **i** and is delivered for use through the pipe **l**.

The filtering material is taken out when the impurities are removed, and cleansed for future use.

The chemicals are charged into the tank **e** by the pump **g**. The quantity of chemicals which should be used may vary from time to time; this is regulated by simply adjusting a valve which needs no further attention until a change in proportions is required.

Water-heating apparatus.—The softening efficiency is increased by quite 30 per cent. if the water to be treated is delivered into the tank **d** at a temperature of not less than 130° Fahr. and if there are no existing facilities for heating, it is desirable to have them with the apparatus. The capacities tabulated are, in all cases, those obtained with water at 130° Fahr.

Water meter.—At an additional cost of £10 to £15 the softener is provided with appliances which indicate the quantity of water treated.

The value of records of this kind, although so rarely provided for in connection with steam boilers—is so well-known that it is unnecessary to recommend the adoption of the meter. It is perhaps equally useful in many industrial operations.

The prices include all fittings and connections excepting those required to convey the water to the softener for treatment and from it when treated.

PRICES OF CYLINDRICAL WATER SOFTENERS, Fig. 2632.

Capacity, gallons per hour	3300	4400	5500	6600	7700	8800	11000
Price of apparatus	£285	£335	£405	£460	£620	£680	£790
„ Water heater	£15	£17	£19	£30	£32	£34	£36

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

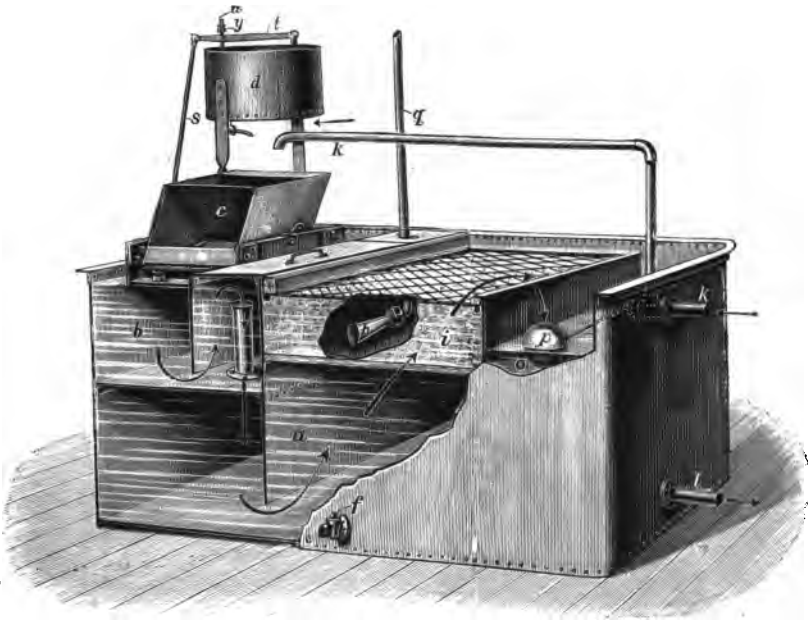


Fig. 2633.

RECTANGULAR WATER SOFTENING APPARATUS. Fig. 2633 represents the apparatus in its most complete form, with water heater and feed water tank, but several modifications are made to suit existing conditions in regard to water heating, storage, etc.; for this reason the prices are given for the apparatus without water heater and feed water tank for use in connection with existing appliances for heating and storage. Softeners of this construction are made of all capacities up to about 2000 gallons per hour.

PRICES OF RECTANGULAR WATER SOFTENING APPARATUS.

Capacity, galls per hour ...	55	100	150	225	400	650	1000	1450
Price of apparatus, Fig. 2633	£26	£40	£48	£60	£68	£110	£136	£177
„ „ without heater and storage tank }	£17	£26	£32	£42	£60	£82	£100	£132

The cost of packing for shipment and delivery f.o.b. is about 5 per cent.

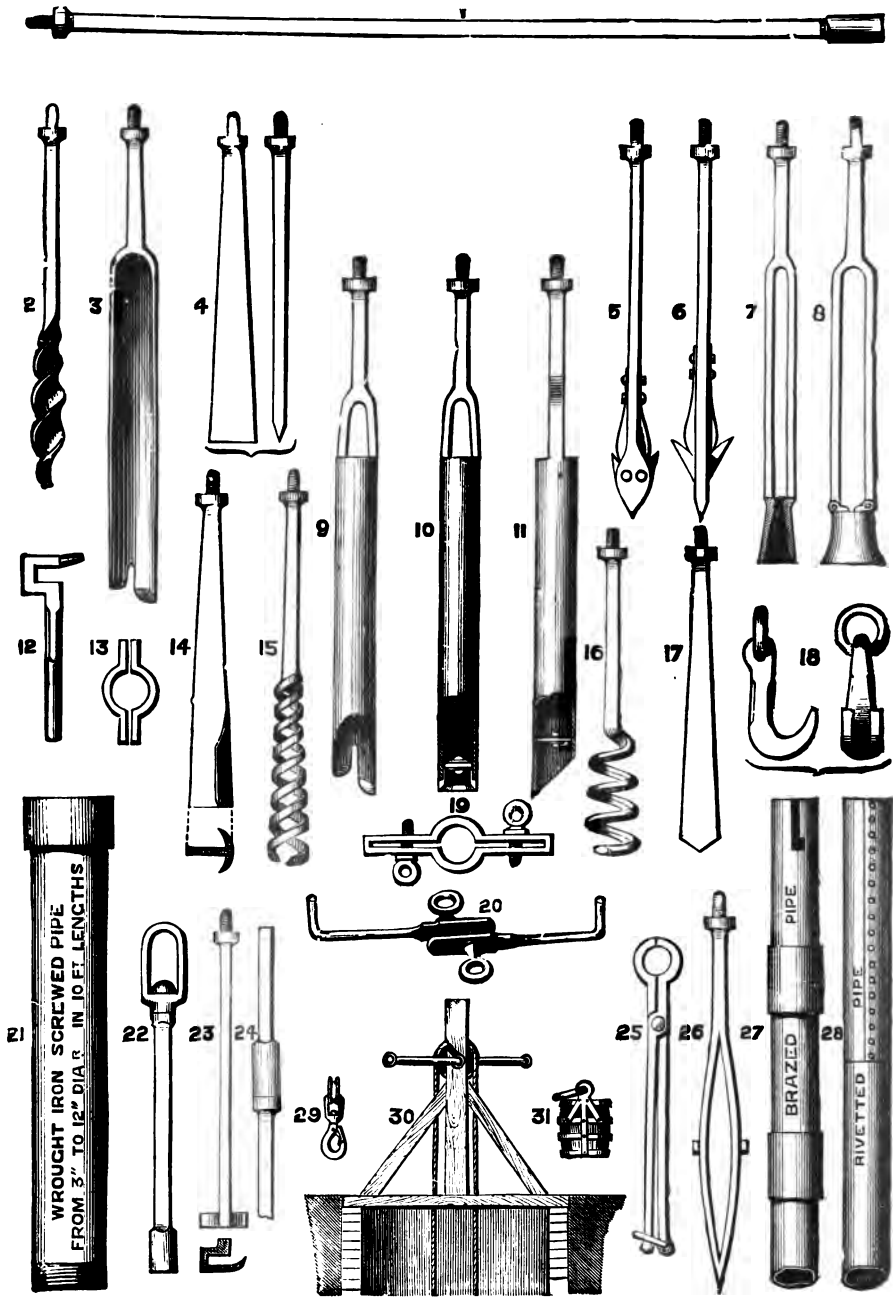


Fig. 2634.

WELL BORING AND PROSPECTING TOOLS.

This subject is referred to at pages 27 to 37 of Section VI. where details will be found of various types of diamond drilling machinery, percussion drills and appliances connected with them which have been largely and successfully used in all parts of the world.

Boring artesian wells, as well as prospecting for coal and minerals have been carried out by the diamond drill to depths varying from a few hundreds, to more than 4000 feet.

BORING TOOLS for testing ground for minerals, foundations, water, &c., have been designed to suit the varied conditions under which they have to work ; those in general use are illustrated on the annexed page, Fig. 2634, and consist of :—

- 1.—Well rod, usual length 10 feet.
- 2.—Worm auger.
- 3.—Open auger, for clay.
- 4.—Flat chisel, for stone or flint.
- 5.—Spring dart to draw faulty pipes from the bore hole.
- 6.—Ditto ditto, for smaller pipes.
- 7.—Bell screw, for withdrawing broken rods.
- 8.—Bell box, for ditto
- 9.—Auger nose shell, with valve for loose soil or sand.
- 10.—Flat nose shell, for similar purposes.
- 11.—Shoe nose shell, for harder ground.
- 12.—Hand dog, for screwing and unscrewing the rods.
- 13.—Pipe clamps or rests.
- 14.—T-chisel, for flint or stone.
- 15.—Wad hook, for withdrawing stones, &c., which may fall into the bore hole.
- 16.—Spiral angular worm for withdrawing broken rods.
- 17.—Diamond or drill-pointed chisel, for hard ground.
- 18.—Lifting dog, for raising and lowering the rods.
- 19.—Long pipe clamps or rests.
- 20.—Tillers or levers for turning the rods.
- 21.—Wrought iron screwed well bore pipe.
- 22.—Short rod, with swivel head.
- 23.—Crow's foot for extracting the broken rods from bore hole.
- 24.—Pair of well rod joints ready to shut up for greater lengths.
- 25.—Pipe tongs or heaters for making joints in pipes.
- 26.—T-piece or pipe dog for lowering the pipes.
- 27.—Brazed and collared pipe, with water-tight soldered joints.
- 28.—Common rivetted pipe, strong make.
- 29.—Spring hook to be attached to well rope for raising tools, &c.
- 30.—Windlass complete, for boring or sinking.
- 31.—Strong well sinking bucket.

The following estimates will suffice to establish the cost, with sufficient accuracy, for an equipment of tools for almost any depth or formation.

BORING PLANT FOR THIRTY FEET DEPTH consists of five 5 ft. lengths of boring rods and one swivel rod, one 2 in. clay auger, one 2 in. shell nose auger with valve, one 2 in. flat chisel, one 2 in. worm auger, one spring hook, one pair of tillers, one lifting dog and two hand dogs or wrenches.

The price of this set of tools is £12 10 0.

BORING PLANT FOR FIFTY FEET DEPTH consists of ten 5 ft. lengths of boring rod and one swivel rod, one clay auger each $3\frac{1}{4}$ and $2\frac{1}{2}$ in., one shoe nose shell with valve each 3 and 2 in., one flat chisel each $3\frac{1}{4}$ and $2\frac{1}{2}$ in., one T chisel each $3\frac{1}{4}$ and $2\frac{1}{2}$ in., one worm auger, one spring hook and 30 ft. of rope, one pair of tillers, two lifting dogs, two hand dogs, one rigger and carriage.

The price of this set of tools is £28.

The price of extra length of boring rod is 18/6 per 5 ft. length.

BORING PLANT FOR ONE HUNDRED FEET DEPTH consists of ten 10 ft. lengths of boring rod and one swivel rod, one clay auger each $4\frac{1}{2}$ and $3\frac{1}{2}$ in., one shoe nose shell with valve each 4 and 3 in., one auger nose shell each 4 and 3 in., one flat chisel each $4\frac{1}{2}$ and $3\frac{1}{2}$ in., one T chisel each $4\frac{1}{2}$ and $3\frac{1}{2}$ in., one worm auger, one spring hook and 30 ft. of rope, one pair of tillers, two lifting dogs, two hand dogs, one bell box, one rigger and carriage, one auger board and one auger cleaner.

The price of this set of tools is £40.

The price of extra boring rods, £1 1 0, is per 10 ft. length.

BORING PLANT FOR TWO HUNDRED FEET DEPTH consists of twenty 10 ft. lengths of boring rod and one swivel rod, one clay auger each $5\frac{1}{2}$, $4\frac{1}{2}$ and $3\frac{1}{2}$ in., one shoe nose shell with valve each 5, 4 and 3 in., one auger nose shell each 5, 4 and 3 in., one flat chisel each $5\frac{1}{2}$, $4\frac{1}{2}$ and $3\frac{1}{2}$ in., one T chisel each $5\frac{1}{2}$, $4\frac{1}{2}$ and $3\frac{1}{2}$ in., one worm auger, one spring hook with 30 ft. of rope, one pair of tillers, two lifting dogs, two hand dogs, one bell box, one rigger and carriage, one auger board, and one auger cleaner.

The price of these tools is £64.

The price of extra boring rods, £1 4 0, is per 10 ft. length.

BORING PLANT FOR THREE HUNDRED FEET DEPTH consists of thirty 10 ft. lengths of boring rod and one swivel rod, one clay auger each $6\frac{1}{2}$, $5\frac{1}{2}$ and $4\frac{1}{2}$ in., one shoe nose shell with valve each 6, 5 and 4 in., one auger nose shell each 6, 5 and 4 in., one flat chisel each $6\frac{1}{2}$, $5\frac{1}{2}$ and $4\frac{1}{2}$ in., one T chisel each $6\frac{1}{2}$, $5\frac{1}{2}$ and $4\frac{1}{2}$ in., one S chisel each $6\frac{1}{2}$, $5\frac{1}{2}$ and $4\frac{1}{2}$ in., one worm auger, one crows foot, one bell box, one spiral worm, one spring hook with 30 ft. of rope, one snatch block, one pair of tillers, two lifting dogs, two hand dogs, one bell box, two rod rests, one rigger and carriage, one auger board and one auger cleaner.

The price of these tools is £96.

The price of extra boring rods, £1 4 0, is per 10 ft. length.

BORING PLANT FOR FIVE HUNDRED FEET DEPTH consists of fifty 10 ft. lengths of boring rod and one swivel rod, one clay auger each $8\frac{1}{2}$, $7\frac{1}{2}$, $6\frac{1}{2}$ and $5\frac{1}{2}$ in., one flat chisel, one T chisel and one S chisel each $8\frac{1}{2}$, $7\frac{1}{2}$, $6\frac{1}{2}$ and $5\frac{1}{2}$ in., one shoe nose shell with valve and one auger nose shell each 7, 6, 5 and 4 in., two worm augers, two bell boxes, one crows foot, one bell screw, two pairs of tillers with spare screws, two lifting dogs, four hand dogs, two rod rests, one spring hook with 30 ft. of rope and snatch block, one rigger and carriage, one auger board and cleaner.

The price of these tools is £178.

The price of extra boring rods, £1 12 0, is per 10 ft. length.

Boring plant for 1000 ft. depth cost about	...	...	...	£440	0	0
Extra length of boring rod, per 10 ft. length	...	...	...	£2	4	0
Ironwork for shear legs	...	...	...	£3	0	0
Sinkers' windlass for wells up to 200 ft. depth	...	...	...	£12	0	0
Do. do. do. 300 do.	...	...	...	£24	0	0
Do. do. do. 1000 do.	...	...	...	£38	0	0

LINING TUBES FOR BORE HOLES are usually made with swelled or flush screwed ends.

PRICES OF LINING TUBES FOR BORE HOLES.

External diameter... inches	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	6	8	10	12
Brazed and collared pipes, per foot	2/7	2/10	3/-	3/2	3/4	4/4	6/-	8/-	11/-
Swelled and screwed end ..	1/6	1/9	2/-	2/-	2/3	2/9	3/9	...	...
Flush screw end	2/4	2/8	3/3	3/9	4/6	5/8	9/4	13/6	23/-
Steel driving collars and shoes ...	13/-	16/6	20/6	25/-	30/-	38/6	50/-	75/-	120/-

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

ARTESIAN WATER SUPPLY, which rises above the surface, is usually collected into a main pipe connected with the bore pipe, and controlled by a valve.

When this is not the case, a bore hole pump similar to Fig. 2597 (or other suitable type) is inserted in the bore hole and is driven by a direct acting engine, a pumping arm, or in other convenient manner.



Fig. 2635.

SLUICE VALVES, suitable for Water, Steam, Gas, Sewage, etc. are illustrated by Fig. 2635.

The **valve cases** are in cast iron, and fitted with gun-metal screw and nut, four gun-metal faces—two on the body and two on the valve—and are tested by hydraulic pressure to 600 feet head of water (about 18½ kilogrammes per square centimetre) unless specially constructed for a higher pressure.

The **outlets are socket or flanged**, as required; or with flanged and spigot or socket ends; or with spigot and socket ends, to suit the pipes to which they are to be connected.

The **cost of facing flanges** is given below; also of hand-wheels, keys for valves, etc. The flanges for the smaller sizes of valves are faced all over, but the larger sizes have the flanges faced only from the bore to the inner edge of the bolt holes.

The **bolt holes** are usually made to a standard for each size of valve; but where the valves are to connect with existing pipes, the holes will be drilled to a template, or sketch with figured dimensions showing what is required.

The **valve spindle** is provided with a socket to take a key or to connect it with a hand-wheel.

The **proportions of the valves** are ample to withstand the concussions and other contingencies met with in ordinary service, and the materials and workmanship are as required in the best water works practice.

PRICES OF SOCKET OR FLANGED SLUICE VALVES.

Diameter inches	2	2½	3	4	5	6	7	8	9	10	12
Price with flanged or socket ends	30/-	36/-	45/-	54/-	75/-	89/-	113/-	150/-	167/-	232/-	285/-
„ with loose flanged socket and spigot ends, extra	5/6	6/9	7/9	11/-	15/-	18/-	25/-	27/-	33/-	42/-	72/-
Hand-wheel, extra	2/3	2/6	3/-	3/3	3/6	4/-	4/6	5/6	6/6	8/-	10/-
Facing flanges „	1/2	1/4	1/9	2/-	2/3	2/7	2/10	3/2	3/6	4/-	5/3

LARGE SURFACE BOXES each 10/6.

WROUGHT IRON KEYS FOR SLUICE VALVES.—Black 15/-; bright, 20/-

GUN METAL SLUICE VALVES, wedge system, for steam or water, the ends screwed for iron tube.

PRICES OF GUN METAL SLUICE VALVES.

Internal diameter inches	1	1½	2
Price of valve	19/-	27/6	33/-

FIRE HYDRANTS admit of the full pressure in the main being instantly available, or of controlling it to any extent desired, without waste of water. Many other forms of Hydrants and Stand pipes are made for fire service and other purposes, but those illustrated by Fig. 2636 to 2638 sufficiently represent the types used for controlling the supply to railway stations, warehouses, etc. for fire and general service.

The **surface box**, Fig. 2639, gives access to the hydrant without disturbing the surface of the road.

The **hydrant** Fig. 2636 represents a double branch stand pipe attached to a hydrant 2½ inches diameter, ready for use. The ball **A** (of low specific gravity) is kept in position by the pressure of water against it, and is depressed to the extent required by the spindle with screwed end, in the stand pipe. The same stand pipe can be attached to either of the other hydrants.

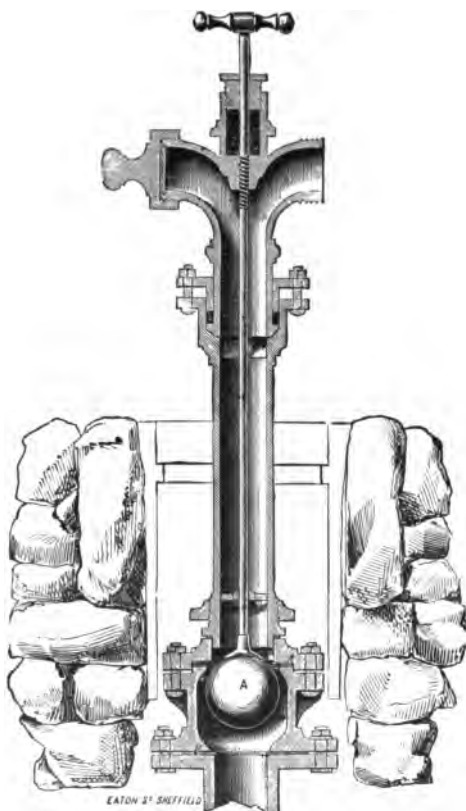


Fig. 2636.

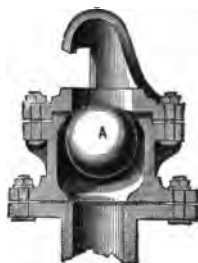


Fig. 2637.

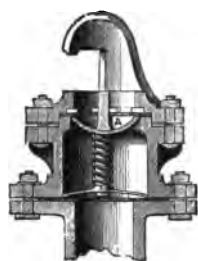


Fig. 2638.

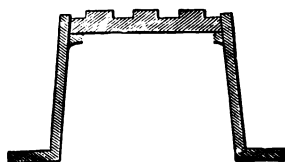


Fig. 2639.

The price of the **Stand Pipe**, Fig. 2636, with double branch in copper is £5 5 0
 " " " " single " " £4 5 0
 " " " " double branch wrought iron stem £4 15 0

The price of the **Hydrant**, Fig. 2637, with 2½ in. ball is 7/-, or with 3 in. ball 9/-
 " Spring Hydrant, Fig. 2638, ordinary size is 13/6, or with 3 in. ball, 17/6.
 " cast iron surface box, Fig. 2639, with chain and cover is 9/6.
 " " " " with lock or hinge to cover, 11/-
 " " " " with lock and hinge to cover, 12/6.

WATER METERS.—The maximum quantities, which will be accurately and safely registered by Kennedy water meters, are indicated in the subjoined table, and these quantities should in no case be exceeded. They are made of all capacities up to 100,000 gallons per hour.

Meters to measure water, and all meters measuring small quantities, should be brass-lined.

In determining the size of meter to be employed it should be borne in mind that the mean flow from a single acting pump is about one-sixth of the maximum flow, and that of double acting pumps about one-third of the maximum flow; the size selected should, therefore, be that equal to the maximum flow.

The pipe connections to the meter, unless otherwise specified, are adapted for lead pipe of the dimensions indicated.

Boiler meters are graduated to tenths of the quantities registered by the ordinary water meter, and the piston packing being of indiarubber, the temperature of the water measured must not exceed 120° F.

If the temperature of the water exceeds 120° F., a metal piston with gun-metal rings is used.

PRICES OF KENNEDY METERS.

Capacity, gallons per hour	1000	1500	2500	4000	7500	10000	18000	32000
Diameter of pipe... inches	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	3	4
Price of water meter ...	£3 16	£5 9	£6 13	£9	£14 11	£22 14	£31 18	£42 18
„ „ brass lined	£4	£5 15	£7	£9 10	£15 10	£24	£34	£46
Price of boiler meter ...	£5 6	£7 1	£8 8	£11 10	£17 16	£26 14	£37 8	£50 8
„ „ brass lined	£5 15	£7 15	£9 5	£13	£20 14	£31 2	£44 13	£61 13
„ „ dirt box... ..	7/6	8/-	8/-	12/-	16/-	33/-	55/-	75/-

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

SELF-REGISTERING WATER METER.—Any of the above-named meters are made self-registering by applying a 24-hour clockwork with drum for diagram paper, and a apparatus which indicates diagrametrically the waste of water and rate of flow in the main throughout the 24 hours.

The extra cost of self-registering apparatus for any size of meter is £4 10 0

WROUGHT IRON WELL PUMP RODS.—The section is increased at the joint to retain the full strength, and a gun-metal socket securely couples the ends.

The following prices per foot are for rods 12 feet long.

Diameter of rods inch	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{7}{8}$	1	$1\frac{1}{2}$
Price of rod per foot	-/7	-/9	1/1	1/7	2/3

BRASS WELL ROD GUIDES OR CLEATS, Fig. 2640.



Fig. 2640.

Diameter of rod, inch	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{7}{8}$	1	$1\frac{1}{2}$
Price of guide ...	4/-	4/-	4/6	5/-	7/6

ROLLER WELL ROD GUIDES IN FRAME, Fig. 2641.

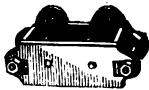


Fig. 2641.

Diameter of rod inch	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{7}{8}$	1	$1\frac{1}{2}$
Price of single rod guide ...	3/-	3/6	5/-	7/-	9/-
„ double „ ...	7/6	8/6	10/-	12/-	18/-
„ treble „ ...	13/-	14/-	16/-	19/-	25/-

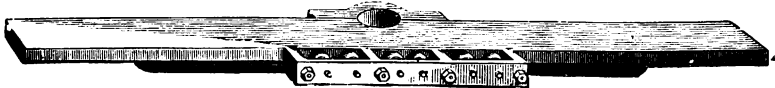


Fig. 2642.

CAST IRON WELL STAGES WITH ROLLER GUIDES AND PIPE CLIP, Fig. 2642, for wells 4 feet 6 inches diameter, or to secure to bearers.

Diameter of pump inches	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Price of stage, single pump	17/-	19/-	20/-	22/-	30/-	35/-
„ double „	23/-	25/-	30/-	32/-	40/-	45/-
„ treble „	27/-	29/-	37/-	40/-	47/-	52/-

CAST IRON PUMP STAGES strongly ribbed to carry the pumps and to fix in wells 4 feet 6 inches diameter, or to be secured to bearers.

Diameter of pump inches	2½	3	3½	4	4½	5
Price of stage, single pump	30/-	32/-	35/-	38/-	50/-	54/-
„ double „	35/-	37/-	50/-	52/-	55/-	60/-
„ treble „	38/-	40/-	55/-	60/-	68/-	70/-

PRICES OF DRESSED CUP LEATHERS FOR PUMPS,
Fig. 2643.



Fig. 2643.

Diam. inches	1	2	2½	3	3½	4	4½	5
Price ... each	-/9	-/10	-/11	1/2	1/5	1/9	2/-	2/3

Diam. inches	6	6½	7	8	9	10	11	12
Price ... each	3/6	4/-	4/7	5/9	7/6	8/6	9/6	10/6

HYDRAULIC PUMP LEATHERS.

Diameter inches	¾	1	1½	1½	1¾	2	2½	3
Price each	-/9	-/10	1/-	1/3	1/5	1/9	2/1	2/6

HYDRAULIC RAM LEATHERS.

Diameter inches	2	2½	3	3½	4	4½	5	6	7
Price each	2/6	3/-	3/6	4/-	4/6	5/-	5/9	7/-	8/-

Diameter inches	8	9	10	11	12	13	14	15	16
Price each	9/-	10/6	11/6	12/6	13/9	15/-	16/-	17/-	18/6

QUILTED CUPS FOR HOT LIQUORS, Fig. 2644.



Fig. 2644.

Diameter inches	2	2½	3	3½	4	5	6	7	8
Price... .. each	-/10	1/2	1/3	1/5	1/8	2/3	2/9	3/5	3/11

QUILTING FOR HOT LIQUORS.

Width inches	1½	1½	1¾	2	2½	3
Price per yard	1/2	1/4	1/5	1/7	2/-	2/4

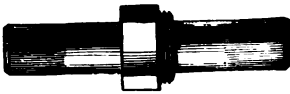


Fig. 2645.

GUN-METAL UNIONS, Fig. 2645, for lead pipe.

Diam. of pipe, inch	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
Price of joint ...	1/6	2/-	2/3	2/9	4/6	6/6	8/3	10/-



Fig. 2646.

GUN-METAL UNIONS, Fig. 2646, one end screwed for iron and the other tinned for lead pipe.

Diam. of pipe, inch	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
Price of joint ...	2/3	2/9	3/3	4/3	7/-	9/-	10/9	12/6

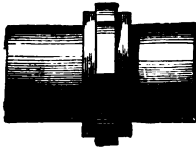


Fig. 2647.

GUN-METAL UNIONS, Fig. 2647, screwed for wrought iron tube.

Diam. of pipe, inch	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2
Price of joint ...	4½	6	9½	1/1½	2/-	3/-	3/9	6/8

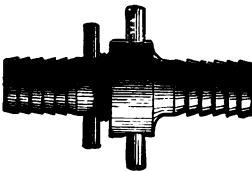


Fig. 2648.

GUN-METAL HOSE UNIONS, Fig. 2648.

Diameter of pipe, inch	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	3
Price of joint...	3/10	4/8	5/6	7/3	8/6	9/-	14/6

GUN-METAL CONNECTOR for hose to stand pipe, etc., $2\frac{1}{2}$ inch, 9/-



Fig. 2649.

COPPER TAPER BRANCH PIPE, Fig. 2649, with gun-metal nozzle, lugs, and male screw for hose.

Diameter of hose ...	... inches	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	3
Price of branch pipe ...	...	12/-	14/6	16/-	20/-	22/-	24/-	27/6

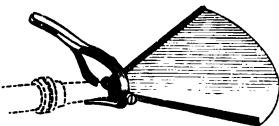


Fig. 2650.

GUN-METAL SPREADER, Fig. 2650, to attach to branch pipe.

Diam. of branch pipe	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$
Price of spreader ...	2/-	2/3	2/9	3/3	4/-	5/-

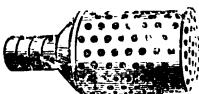


Fig. 2651.

COPPER SUCTION ROSE, Fig. 2651.

Diam. of stem, inches	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{4}$	3
Price of rose ...	4/6	5/-	5/6	7/-	9/-	10/-



Fig. 2652.

GUN-METAL FOOT VALVE AND STRAINER, Fig. 2652, screwed for connection with pump or injector suction pipes.

Diam. of pipe, inch	1	1½	1½	2	2½
„ strainer „	2	2½	3	3½	4
Price of foot valve	3/6	5/3	7/-	11/-	18/-
„ strainer ...	2/9	4/-	4/6	6/6	10/6
„ complete	6/3	9/3	11/6	17/6	28/6

CAST-IRON FOOT VALVE AND STRAINER.—The flange connecting the valve chamber with the suction pipe is faced, and is complete with bolts, nuts and washers. The strainer is attached to the foot valve chamber and is easily removed when the valve needs attention.

Internal diam. of pipe, inches	2	2½	3	4	5	6	7	8
Price of valve and strainer ...	15/-	17/-	24/-	34/-	45/-	60/-	95/-	105/-

COPPER PEAR SHAPED AIR VESSELS with dip pipe.

Diameter of pipe inches	1½	1½	1¾	2
Price of air vessel	20/-	25/-	30/-	35/-

CAST IRON AIR VESSELS, similar to that shown in Fig. 2519, for high pressures, with faced flanges and copper dip pipe.

Diameter of pipe inches	1½	1½	2	2½	3	3½	4
Price of air vessel	25/-	27/-	35/-	55/-	75/-	90/-	120/-

PIPES, CONNECTIONS, Etc.

CAST IRON PUMP PIPES AND CONNECTIONS WITH FACED FLANGES.—The following prices are for standard lengths of 6 feet for pipes up to 2½ inches internal diameter; larger sizes are made up in 9 feet lengths.

PRICES OF CAST IRON PUMP PIPES AND CONNECTIONS WITH FACED FLANGES.

Diameter of pipe ... inches	2	2½	3	4	5	6	7	8
Price of pipe, per foot... ..	1/-	1/2	1/6	2/-	2/9	3/6	5/-	6/-
„ bend each	4/3	6/-	7/-	10/-	13/6	16/6	26/-	34/-
„ T piece	6/-	7/6	9/-	12/-	16/-	19/6	32/-	35/-
„ bolts, washers, &c. per joint	1/2	1/4	1/9	2/3	3/-	3/9	5/6	6/6

GALVANIZED WROUGHT IRON FLANGED PIPES, WITH BOLTS, WASHERS, &c. FOR JOINTS.

Internal diameter of pipe ... inches	2	2½	3	3½	4	5	6
Price of pipe per foot	2/9	3/6	4/1	4/9	6/2	9/-	12/4

TINNED COPPER PIPES, to carry liquids which act on other metals, or which must be exceptionally free from contamination, necessarily vary in price with the current prices of metals, the sections required, etc., but for plain pipes tinned internally they will probably be approximately as follows :

Diameter of tinned pipe ... inches	1	1½	2	2½	3	3½	4
„ pump barrel ... „	2	3	4	5	6	7	8
Price of tinned pipe ... per foot	1/6	1/10	2/8	3/6	5/-	6/-	7/-

SEAMLESS COPPER TUBE.—The following table gives the approximate weight per foot, of the standard diameters and sections, usually ready for delivery in lengths not exceeding 15 feet, but other diameters, sections and lengths, are made at short notice.

The weight per foot is approximately correct, but cannot be guaranteed.

The thickness of metal in Nos. of Imperial wire gauge, is also given in decimals of an inch and, approximately, in millimetres for facility in calculating safe working pressures, these thicknesses may, however, vary slightly.

Prices change from time to time, but may probably range from 10 to 12 pence per lb.

WEIGHTS OF SEAMLESS COPPER TUBE.

Thickness Imperial wire gauge	...	...	8	10	12	14	16
"	...	...	160	128	104	080	060
"	...	...	4.06	3.25	2.65	2.03	1.53
Internal diam., 1 inch	...	...	...	...	...	...	24
"	1 1/2	"	...	...	...	...	34
"	2	"	...	...	...	...	44
"	2 1/2	"	...	...	...	68	...
"	3	"	...	1.36	1.07	.80	...
"	3 1/2	"	...	1.75	1.39	1.04	...
"	4	"	...	2.13	1.70	1.29	...
"	4 1/2	"	...	2.52	2.02	1.53	...
"	5	"	4.18	3.29	2.65	2.01	...
"	5 1/2	"	4.66	3.68	2.96	2.25	...
"	6	"	5.15	4.07	3.28	2.50	...
"	6 1/2	"	5.12	4.84	3.90	2.98	...
"	7	"	7.08	5.62	4.53	3.46	...
"	8	"	8.05	6.39	5.16	3.95	...

PRICES OF CAST IRON SOCKET PIPES AND CONNECTIONS.

Internal diameter	... inches	2	2½	3	3½	4	4½
Thickness	... "	½	⅝	⅞	1	1½	1¾
Ditto	... m/m	6.35	7.94	7.94	7.94	8.73	9.52
Length when laid	... feet	6	9	9	9	9	9
Ditto	ditto	metres	1.829	2.134	2.134	2.134	2.134
Weight per length	... cwts.	0 1 14	0 3 0	0 3 14	1 0 14	1 1 14	1 2 14
Ditto	metre	... kilog.	10.40	13.88	16.20	20.83	30.10
Price per yard	... "	1/1	1/3	1/5	1/10	2/3	2/6
Lead for joint	... lbs.	1.7	2	2.4	3	3.6	5.3
Price of elbow	... each	1/10	2/5	3/1	4/-	5/-	6/2
Do.	¼ bend	... "	2/6	3/3	4/5	5/9	8/-
Do.	T piece	... "	4/4	5/10	7/2	8/1	9/2
Do.	branch	... "	4/11	6/6	7/6	9/9	11/-
Do.	collar	... "	1/6	2/2	2/5	2/8	3/3
Do.	cap	... "	-/9	-/10	1/4	1/10	2/1
Do.	syphon and cover	... "	15/9	19/6	21/3	21/9	23/6

Internal diameter	... inches	5	6	7	8	10	12
Thickness	... "	⅝	¾	⅞	1	1½	1¾
Ditto	... m/m	10.32	10.32	11.11	11.91	14.29	13.49
Length when laid	... feet	9	9	9	9	9	9
Ditto	ditto	metres	2.134	2.134	2.134	2.134	2.134
Weight per length	... cwts.	1 3 14	2 1 14	2 3 14	3 1 14	4 3 0	5 3 21
Ditto	metre	... kilog.	34.72	44.00	53.24	62.50	88.00
Price per yard	... "	2/10	3/7	4/9	5/6	7/9	9/9
Lead for joint	... lbs.	6	8.2	8.7	9.9	14.9	17.2
Price of elbow	... each	7/2	9 6	13/2	14/8	24/9	...
Do.	¼ bend	... "	9/6	13/8	19/9	22/2	33/9
Do.	T piece	... "	11/4	15/3	21/6	28/5	38/3
Do.	branch	... "	13/1	15/6	27/-	29/9	41/9
Do.	collar	... "	3/7	5/2	6/5	7/1	9/-
Do.	cap	... "	2/6	3/1	4/2	5/4	7/9
Do.	syphon and cover	... "	25/-	32/6	46/9	48/6	63/-

Connections for other sections of metal or special forms range in price from about £10 to £12 per ton.

PRICES OF CAST IRON FLANGED PIPES.

Internal diameter	... inches	2	2½	3	3½	4	4½
Thickness	... "	⅝	¾	⅞	1	1½	1¾
"	... m/m	7.14	8.73	7.94	8.73	9.52	10.32
Length when laid	... feet	6	6	9	9	9	9
"	... metres	1.829	1.829	2.134	2.134	2.134	2.134
Weight per length	... cwts.	0 1 21	0 2 11	1 0 0	1 0 21	1 1 21	1 3 0
"	per metre	... kilog.	12.15	16.60	18.50	22.00	26.62
Price per yard	... "	1/7	1/11	2/1	2/4	2/9	3/4

Internal diameter	... inches	5	6	7	8	10	12
Thickness	... "	⅞	1	1½	1¾	2	2½
"	... m/m	11.11	12.70	12.70	13.49	15.88	17.46
Length when laid	... feet	9	9	9	9	9	9
"	... metres	2.134	2.134	2.134	2.134	2.134	2.134
Weight per length	... cwts.	2 0 14	2 3 0	3 1 7	3 3 14	5 3 14	7 3 0
"	per metre	... kilog.	39.35	50.95	61.35	71.76	108.80
Price per yard	... "	4/-	5/1	6/8	7/9	11/9	15/6

FACING FLANGES OF PIPES, ELBOWS, T-PIECES, and other connections between the bore and the inside of the bolt holes, or over the whole surface of the flange, is usually charged at about the following rate.

Internal diameter of pipe inches	2½ to 4½	5 to 6	7 to 8	9 to 12
Price for turning the facing strip pipes	7/-	9/-	1/3	1/11
" " " " connections	1/3	1/6	2/8	3/9
" " " " across the flange pipes	1/11	1/3	1/11	2/8
" " " " connections	1/9	2/6	3/9	5/8



Fig. 2653.

STEEL AND WROUGHT IRON PIPES of the kinds indicated by Figs. 2653 to 2655 are about one-fifth the weight of cast iron pipes of equal diameter and resistance to pressure; they are therefore used with great advantage for conveying water, compressed air for mining, and for many other purposes, where the cost of transport and handling form important items in the total cost of an installation.

LAP-WELDED TUBES WITH FLANGES, Fig. 2653, are made in lengths of 11 to 19 feet, according to their diameter; every tube is tested to 1000 lbs. per square inch, and may be used for working pressures up to 300 lbs. per square inch, the thickness of metal and the cost being increased for tubes required to carry higher pressures, and tested accordingly.

The flanges are of steel or malleable iron, and are fixed on the tubes or sent separately, as may be convenient; the prices include bolts, nuts, and washers for the joints.

Branch service connections are made, but they vary so widely in details that prices cannot conveniently be tabulated.

PRICES OF STEEL AND WROUGHT IRON TUBES WITH FLANGES, Fig. 2653.

Internal diameter ... inches	1½	2	2½	3	3½	4	4½	5
Thickness ... decimals of inches	.092	.104	.116	.128	.128	.144	.160	.160
Do. Standard W.G. No.	13	12	11	10	10	9	8	8
Prices of Tubes ... per foot	10½/-	1/1	1 6	1/11	2/6	3/-	3/9	4/6
Do. Bends, steel... each	10/-	12/-	15/-	18/-	24 -	30/-	40/-	50/-
Do. Elbows	14/6	16/6	18 6	21/6	25/-	30/-	36/-	42/-
Do. T pieces	20/-	22/-	24/6	29/-	33/6	40/-	49/-	56/-
Connecting or reducing pieces	6/-	8/-	10/-	12 -	14/-	17/-	23/-	27/-

Internal diameter ... inches	5½	6	7	8	9	10	11	12
Thickness .. decimals of inches	.176	.176	.192	.192	.232	.252	.300	.300
Do. Standard W.G. No.	7	7	6	6	4	3	1	1
Prices of Tubes ... per foot	5/3	6/-	8/-	10/-	13/-	18/6	24/-	28/-
Do. Bends ... each	80/-	95/-	115/-	165/-	220/-	280 -	340/-	400/-
Do. Elbows	48/-	55/-	70/-	90/-	105/-	125/-	150/-	175/-
Do. T pieces	64/-	74/-	95 -	120/-	140/-	165/-	185/-	210/-
Connecting or reducing pieces	32/-	37/-	48/-	60 -	70 -	85/-	100/-	120/-

RIVETTED STEEL PIPES WITH SOCKET OR FLANGED JOINTS, Figs. 2654 and 2655, are made to any length up to 25 feet and of any diameter from 3 to 60 inches; they are usually coated with a composition which protects them from corrosion and has no injurious effect on water.

Thickness and weight.—Being made of rolled steel of relatively high tensile strength but very ductile, these pipes built of plates ⅜ of an inch thick are equal in strength to cast iron pipes 1 inch thick and much more elastic.

They are usually made of the lightest section mentioned, but other thicknesses of plates are tabulated in Nos. of Standard Wire Gauge and in equivalent decimals of an inch, to facilitate calculations to ascertain the section requisite for a given internal pressure, the distance between supports, etc.



Fig. 2654.



Fig. 2655.

Economies in final cost.—If the sockets or flanges are sent loose for fixing when the pipes are laid, the pipes can be nested within each other and so reduce the cost of freight.

A further sensible economy is made by rivetting up long lengths of pipe and decreasing the number of joints.

The prices per foot are for pipes not less than 20 feet long, coated with composition, and include washers, bolts, etc., for flanged joints, but not lead and hemp for socket joints. For the approximate weight of lead for joints, see prices of Cast Iron Socket Pipes.

PRICES OF RIVETTED STEEL PIPES, Figs. 2654 and 2655.

Internal diameter ... inches	6	7	8	9	10	11	12	13
Thickness Wire Gauge No.	13	13	13	12	12	12	12	11
" ... inch	.092	.092	.092	.104	.104	.104	.104	.116
Price of pipe ... per foot	2/8	3/-	3/4	3/9	4/1	4/5	4/9	5/6
Thickness Wire Gauge No.	12	12	12	11	11	11	11	10
" ... inch	.104	.104	.104	.116	.116	.116	.116	.128
Price of pipe ... per foot	2/9	3/1	3/5	4/-	4/4	4/8	5/1	6/3
Thickness Wire Gauge No.	11	11	11	...	...	...	10	9
" ... inch	.116	.116	.116	.125	.125	.125	.128	.144
Price of pipe ... per foot	3/-	3/4	3/8	4/6	4/10	5/2	5/11	6/10

Internal diameter ... inches	14	16	18	20	22	24	27	30
Thickness Wire Gauge No.	11	11	10	9	9	8	7	...
" ... inch	.116	.116	.128	.144	.144	.160	.176	$\frac{3}{8}$
Price of pipe ... per foot	5/11	6/9	8/2	9/8	10/6	11/11	14/3	16/6
Thickness Wire Gauge No.	10	10	9	8	8	7	...	...
" ... inch	.128	.128	.144	.160	.160	.176	$\frac{3}{8}$	$\frac{3}{8}$
Price of pipe ... per foot	6/7	7/4	8/10	10/3	11/1	13/-	15/-	16/6
Thickness Wire Gauge No.	9	9	8	7	7	...	...	...
" ... inch	.144	.144	.160	.176	.176	$\frac{3}{8}$	...	...
Price of pipe ... per foot	7/2	8/-	9/5	11/4	12/2	13/6	...	...

STEEL OR WROUGHT IRON LAP-WELDED TUBES, for higher pressures than those last referred to, are usually made with plain ends ready for the sockets or flanges to be fixed at destination, or with the "Kimberley" socket joint.

This, or another (loose) socket also for lead joint, is included in the subjoined prices, but other kinds of joints are frequently made of special design to suit the purpose for which the pipes are to be used and—the conditions being clearly defined—there is no difficulty in providing a suitable joint.

The prices of pipes of diameters commonly used will be found below ; but it will be understood that intermediate and larger diameters are made and that prices are in proportion with dimensions—for instance : the price of pipes 23 inches diameter and $\frac{1}{2}$ inch thick is 44/9 per foot.

PRICES OF LAP-WELDED PIPES.

Internal diam. ins.	11	12	14	16	18	20	22	24	26	28	30	33	36
$\frac{3}{8}$ in. thick per ft.	7/11	8/7	10/-	11/4	12/9	14/-	...	...	...	...	30	...	...
$\frac{1}{2}$ in. " "	10/6	11/6	13/4	15/4	17/3	19/1	21/-	...	...	...	...	...	...
$\frac{5}{8}$ in. " "	13/3	14/5	16/9	19/2	21/7	24/-	26/4	28/9	...	...	...	...	...
$\frac{3}{4}$ in. " "	16/-	17/5	20/3	23/1	25/11	28/8	31/6	34/4	37/2	...	...	...	...
$\frac{7}{8}$ in. " "	18/9	20/5	23/10	27/2	30/6	33/10	37/2	40/6	43/10	47/2	50/6	...	...
1 in. " "	21/7	23/6	27/5	31/3	35/2	39/-	42/10	46/9	50/7	54/6	58/5	64/2	70/-
$\frac{1}{2}$ in. " "	24/5	26/7	31/1	35/5	39/10	44/3	48/6	52/10	57/2	61/6	65/10	72/4	78/10
$\frac{3}{8}$ in. " "	27/5	29/11	34/9	39/9	44/9	49/8	54/7	59/6	64/5	69/3	74/2	81/7	89/-

CAST IRON HYDRAULIC MAIN PIPES.—Each pipe is tested by hydraulic pressure to 2500 lbs. per square inch and will carry a working pressure of 700 lbs. per square inch. (about 50 atmospheres). The flanges are faced and fitted with gutta-percha rings, bolts, nuts, etc. ready for laying.

The prices for pipes less than 9 feet long, or for special pieces, is increased to cover the cost of extra flanged joints and the accessories for them.

PRICES OF CAST IRON HYDRAULIC MAIN PIPES.

Internal diameter	...	...	...	... inches	3	4	5	6
Length of pipe	...	...	...	... feet	9	9	9	9
Price of pipe	...	...	...	per foot	2/4	3/7	5/8	7/9
Approximate weight	...	...	...	... lbs.	25	40	65	92

The cost of packing for shipment and delivery f.o.b. may vary from $2\frac{1}{2}$ to 5 per cent.

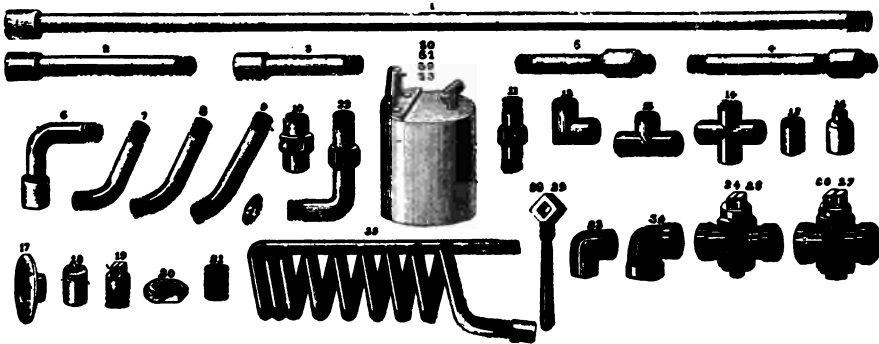


Fig. 2656.

WROUGHT IRON TUBES AND CONNECTIONS for gas, water, steam, compressed air, &c. The tubes are made in lengths up to about 14 feet and can be galvanized if required.

Tubes for steam or for pressures exceeding about 50 lbs. per square inch are subject to a lower rate of discount than tubes for gas, or low pressures. The cost varies with the price of iron, but if the discount for gas tubes is 65 per cent., that for steam tubes will be about 50 per cent.

FLEXIBLE TUBES, HOSE, ETC.

FLEXIBLE METALLIC TUBE is made in steel to carry oils, water or other fluids, and in bronze to withstand pressures up to 200 lbs. per square inch.

It bears a considerable weight without distortion, is quite unaffected by heat or cold, and is used under conditions which cannot be satisfactorily fulfilled by leather, rubber, or any other kind of flexible tube.

PRICES OF FLEXIBLE STEEL TUBE.

Internal diameter, inch	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Price of tube, per foot	-7	-9	-11	1/2	1/8	2/-	2/6	3/8	4/8

The cost of packing for shipment and delivery f.o.b. is 5 per cent.

LEATHER HOSE PIPE, COPPER RIVETTED, is made in two or more qualities, that referred to below is the best quality and suitable for pressures up to about 150 lbs per square inch, as required for steam fire engine service and is preferable, for all purposes, to the lighter and rather cheaper hose pipes.

PRICES OF LEATHER DELIVERY HOSE, COPPER RIVETTED.

Internal diameter	...	...	inches	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{2}$	4
Price per foot	...	...	...	2/6	2/9	3/-	3/3	3/6	3/9	4/6

PRICES OF STRONG LEATHER SUCTION HOSE, COPPER RIVETTED.

Internal diameter	...	...	inches	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4
Price per foot	..	...	...	2/8	3/-	3/4	3/10	4/3	5/1	6/-	7/-

LEATHER FIRE BUCKETS.—**Sewn top**, 12/- each. **Ordinance**, 10/6 each.

VULCANIZED INDIA-RUBBER AND CANVAS HOSE is made in lengths up to 60 feet, and a tube 1 inch internal diameter, of the respective strengths, will carry the under-named pressure of water :

Two-ply, 30 lbs. ; **Three-ply**, 75 lbs. ; **Four-ply**, 175 lbs per square inch.

One-ply withstands little internal pressure.

Hydraulic hose is made to withstand almost any pressure. The maximum working pressure should be stated and whether it is constant or varying. 4-ply hose $\frac{1}{2}$ inch diameter is equal to a working pressure of 2000 lbs. per square inch and 1 inch 1000 lbs

Steam hose.—If possible steam should be shut off at the end of the hose nearest to the boiler, and if it should be required to carry steam of exceptionally high pressure or temperature, these should be defined.

Brewer's hose is prepared (sweetened) for use by brewers, distillers, etc.

Hose with embedded wire is essential for use in raising some liquors and, the bore being smooth, is an advantage in most cases.

PRICES OF VULCANIZED INDIA-RUBBER AND CANVAS DELIVERY HOSE.

Internal diameter	...	...	inches	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$
"	"	...	m/m	9½	13	16	19	25	32	38	44
Price per foot	...	...	1-Ply	-5	-6	-7	-8	-11	1/1	1/3½	1/5½
"	"	...	2-Ply	-6	-7	-8	-9½	1/0½	1/3	1/5½	1/8
"	"	...	3-Ply	-7	-8	-9½	-10½	1/2½	1/5	1/7½	1/10
"	"	...	4-Ply	-9	-10	-10½	1/-	1/4½	1/7½	1/10	2/1
"	"	...	5-Ply	...	...	...	...	1/6½	1/10	2/1	2/4½

PRICES OF VULCANIZED DELIVERY HOSE.

Internal diameter	... inches	2	2½	2¾	3	3½	4	4½	5
"	"	51	57	64	76	89	102	114	127
Price per foot	... 2-Ply	1/10	2/1	2/3½	2/8½	3/1½	3/6	...	...
"	... 3-Ply	2/1	2/4	2/7	3/1	3/7	4/1	4/7	5/-
"	... 4-Ply	2/4½	2/7½	2/11	3/5½	4/-	4/7	5/2	5/9
"	... 5-Ply	2/7½	2/11	3/2½	3/10	4/6	5/2	5/10	6/6

PRICES OF VULCANIZED INDIA-RUBBER AND CANVAS HYDRAULIC HOSE.

Internal diameter	... inches	½	¾	1	1½	2	2½	3
"	... m/m	13	16	19	25	32	38	44
Price per foot	... 3-Ply	1/9	2/-	2/3	2/9	3/3	3/9	4/-
"	... 4-Ply	1/11	2/3	2/6	3/-	3/6	4/-	4/3
"	... 5-Ply	2/2	2/6	2/9	3/3	3/9	4/3	4/6
"	... 6-Ply	2/5	2/9	3/-	3/6	4/-	4/6	5/6

PRICES OF VULCANIZED INDIA-RUBBER AND CANVAS STEAM HOSE.

Internal diameter	... inches	½	¾	1	1½	2	2½	3
"	... m/m	13	16	19	25	32	38	44
Price per foot	... 2-Ply	1/3	1/5	1/6	1/11	2/2	2/5	3/-
"	... 3-Ply	1/5	1/6	1/8	2/-	2/4	2/8	3/5
"	... 4-Ply	1/8	1/9	1/11	2/3	2/8	3/-	3/9
"	... 5-Ply	1/11	2/-	2/2	2/8	3/-	3/5	4/2
"	... 6-Ply	2/2	2/8	2/6	3/1	3/6	3/9	4/6

PRICES OF VULCANIZED INDIA-RUBBER AND CANVAS BREWERS' HOSE.

Internal diameter	... inch	¾	1	1½	2	2½	3	3½
"	... m/m	19	25	32	38	44	51	57
Price per foot	... 2 ply	1/1½	1/5	1/8½	2/7½	2/11	3/2½	3/10
"	... 3 ply	1/2	1/7	1/11	2/2½	2/10	3/6	4/2½
"	... 4-ply	1/3½	1/9	2/1	2/5	3/1½	3/6	4/7
"	... 5-ply	...	1/11	2/3½	2/7½	3/4½	3/9	4/2

PRICES OF VULCANIZED EMBEDDED WIRE SMOOTH BORE SUCTION HOSE.

Internal diameter	... inch	1	1½	2	2½	3	3½	4
"	... m/m	25	32	38	44	51	57	64
Price per foot	... 2-ply	1/6	1/10	2/2	2/10	3/2	3/6½	4/4
"	... 3-ply	1/8	2/-	2/4½	3/1½	3/6	3/11	4/9
"	... 4-ply	1/11	2/3	2/7½	3/5½	3/10½	4/3½	5/1½
"	... 5 ply	...	...	...	3/9½	4/2½	4/8	5/8

The cost of packing for shipment and delivery f.o.b. varies, but is usually about 5 per cent.

VULCANIZED RUBBER AND CANVAS ARMoured FLEXIBLE HOSE has a smooth internal surface, and is protected by wire coiled around it externally. This adds greatly to its resistance under both internal and crushing strains; there is no tendency to kink, or for the armouring to uncoil or loose its grip when the hose is cut.

Hose for steam and hot liquors is made in three different strengths and the subjoined prices are for the medium strengths which suffice for most purposes.

The hydraulic hose is intended to withstand a pressure of 2500 lbs. per square inch, but if hose is required for special purposes, the maximum working pressure should be stated and whether it will be constant or subject to fluctuation.

PRICES OF ARMoured BEST FLEXIBLE DELIVERY HOSE.

Internal diam....inches	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
" " ... m/m	13	19	25	32	38	44	51
Price per foot ... 2 Ply	-/10	$1/1\frac{1}{2}$	$1/5$	...	...	...	...
" " ... 3 Ply	-/11 $\frac{1}{2}$	$1/2\frac{1}{2}$	$1/7\frac{1}{2}$	$1/10\frac{1}{2}$	$2/2$	$2/6$	...
" " ... 4 Ply	...	...	$1/9\frac{1}{2}$	$2/1$	$2/5$	$2/9\frac{1}{2}$	$3/2$
" " ... 5 Ply	...	...	...	...	$2/8$	$3/1$	$3/6$

PRICES OF ARMoured BEST FLEXIBLE DELIVERY HOSE (*continued.*)

Internal diam. inches	$2\frac{1}{2}$	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	5	6
" " ... m m	57	64	76	89	102	127	152
Price per foot ... 5 Ply	$3/4$	$3/8$	$4/5$	$6/3$	...	...	...
" " ... 6 Ply	...	$3/11$	$4/8$	$6/7$	$6/10$	$9/-$	$10/8$

PRICES OF ARMoured HOSE FOR STEAM OR HOT LIQUORS.

Internal diameter ... inches	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{2}$
" " ... m/m	13	19	25	32	38	44	51	64
Price per foot ... best	$2/10$	$3/8$	$4/5$	$6/3$	$7/2$	$8/3$	$10/5$	$13/3$
" " ... 2nd quality	$1/11$	$2/3$	$2/9$	$3/7$	$4/2$	$4/9$	$5/9$	$7/-$

PRICES OF ARMoured BREWERS' HOSE (Sweetened).

Internal diameter ... inches	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{2}$	3
" " ... m/m	19	25	32	38	44	51	64	76
Price per foot ... 3 ply	$1/5$	$1/10$	$2/3$	$2/6$	$3/-$	$3/4$	...	...
" " ... 4 ply	$1/7$	$2/2$	$2/6$	$2/10$	$3/3$	$3/8$	$4/6$	$5/6$

PRICES OF ARMoured HYDRAULIC HOSE.

Internal diameter ... inches	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{7}{8}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$
" " ... m/m	13	16	19	22	25	32	38
Price per foot ...	$3/2$	$4/2$	$5/-$	$5/9$	$6/7$	$8/-$	$9/6$

PRICES OF ARMoured HOSE FOR ACIDS, ETC.

Internal diameter ... inches	$\frac{1}{2}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{2}$	3
" " ... m/m	13	25	32	38	44	51	64	76
Price per foot ...	$1/9$	$3/-$	$3/8$	$4/3$	$4/10$	$5/6$	$6/9$	$8/6$

PRICES OF EMBEDDED WIRE AND ARMoured SMOOTH BORE SUCTION HOSE.

Internal diameter ... inches	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	4	5
" " ... m/m	25	32	38	51	64	76	102	127
Number of plies ...	3	3	3	3	4	4	5	6
Price per foot ...	$2/4$	$2/9$	$3/3$	$4/3$	$5/9$	$7/-$	$10/6$	$15/6$

The cost of packing for shipment and delivery f.o.b. varies, but is usually covered by about 5 per cent.

GALVANIZED WROUGHT IRON OPEN TANKS. The following standard sizes, obtainable at short notice, are made of various sections but are not very durable if less than $\frac{1}{8}$ -inch thick.

The plates of the tanks now referred to are $\frac{1}{8}$ -inch thick, with angle irons round top and bottom and in corners, galvanized and tested before delivery.

PRICES OF GALVANIZED WROUGHT IRON OPEN TANKS.

Capacity gallons	50	70	100	150	200	300	400	500
Length inches	30	32	36	42	48	55	60	66
Width "	19	24	26	30	32	42	48	53
Depth "	24	26	30	33	36	36	39	40
Price of tank	£2 10	£3	£3 16	£4 14	£5 16	£7 10	£9 10	£10 10

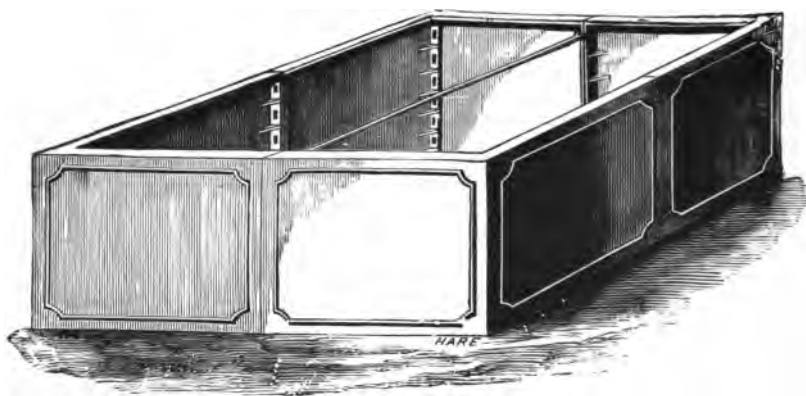


Fig. 2657.

CAST IRON TANKS are built up of plates of dimensions suitable for the capacity and shape of the tank required: The flanges—whether internal or external—have fitting strips which are planed or not, as desired; the joints are made by bolts with iron cement caulking between the flanges.

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